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CASSIER'S MAGAZINE

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THE WORLD'S SEVENTY DREADNOUGHTS

By Archibald S. Hurd

IF the report proves accurate that China, Chili and Argentina are about to place orders in Europe for eight ships of the *Dreadnought* type there will this year be either built, or under construction or authorized no fewer than seventy ships which may be regarded as belonging to the *Dreadnought* era, each representing on an average an expenditure of two millions sterling, and, therefore, aggregating a total outlay of about £140,000,000.

The first ship of this type was laid down as recently as October, 1905. This was the date when the keel plate of the British *Dreadnought* was placed in position at Portsmouth Dockyard under circumstances of unprecedented secrecy. At the time little or nothing was known as to the character of this vessel beyond the fact that she had been designed by the British Board of Admiralty, that she embodied new principles of offense and defense, that the design had been the subject of experiment and had been submitted to the closest scrutiny of a special committee of naval officers, private ship constructors and scientists.

The mystery which surrounded the commencement of this vessel caused other naval powers to hesitate before carrying out plans of construction which had already been prepared. For about twelve months no new armoured ships were laid down in any other country in the world. At last brief details of the *Dreadnought* design began to leak out, and it was discovered that the secret of the ship lay mainly in a thorough-going adoption of the all-big-gun principle. On close examination, it was found to represent the natural sequence in the British story of the evolution of the modern battleship. For many years the British Navy had remained faithful to a type of battleship mounting four 12-inch guns in two barbettes, with a dozen 6-inch guns in casemates and a large number of 12 and 3-pounders for repelling the attacks of torpedo craft. As a result of the development of gunnery as an exact science on the principles worked out by Vice-Admiral Sir Percy Scott (and subsequently introduced into the United States Navy by Commander William Sims), the next step in development was represented by the design of the *King Edward VII.* class, for the design of which Sir William White was responsible as much as a Director of British Naval Construction is ever responsible for the general

character of the vessels ordered by the Board of Admiralty. In these ships the secondary armament of 6-inch guns was reduced in number to ten, and at the four corners of the citadel were placed 4-9.2-inch guns, thus giving the ship eight heavy weapons instead of four, at a sacrifice of two secondary guns. This development of gun power, in association with high speed and increased armour protection, led to the displacement being increased from 15,000 to 16,350 tons. The naval service so thoroughly approved this development in design that the estimates of 1904 made provision for two more ships—the *Lord Nelson* and the *Agamemnon*—in which the principle of developing the fire of the big gun was carried still further, and the whole of the secondary armament of 6-inch guns was eliminated and in their place battleships were produced each mounting four 12-inch guns and ten guns of 9.2-inch

Photograph by Stephen Cribb, Southsea.

STERN OF THE DREADNOUGHT

Photograph by Symonds & Co., Portsmouth.

THE BRITISH BATTLESHIP DREADNOUGHT

This was the stage in British design which had been reached when a change occurred in the constitution of the Board of Admiralty. Admiral of the Fleet Sir John Fisher became First Sea Lord and immediately formed a committee to act in consultation with the Board of Admiralty and the new Director of Naval Construction, Sir Philip Watts, in evolving new types of ships to be included in the naval programme of 1905. This committee laid down the general characteristics of the battleship *Dreadnought* and her boilers and the development of the Parsons marine turbine, had been planned for a speed of 21 knots, while from her three swifter sisters a speed of 25 knots was anticipated, and, as results have since shown, this was exceeded. Admiral Mahan claimed that it was never justifiable to increase the speed of a battleship at the expense of the equivalent weight in gun power, and it was a mistake in particular to substitute heavy turret guns such as the 12-inch for the equivalent weight of the usual intermediate guns. This

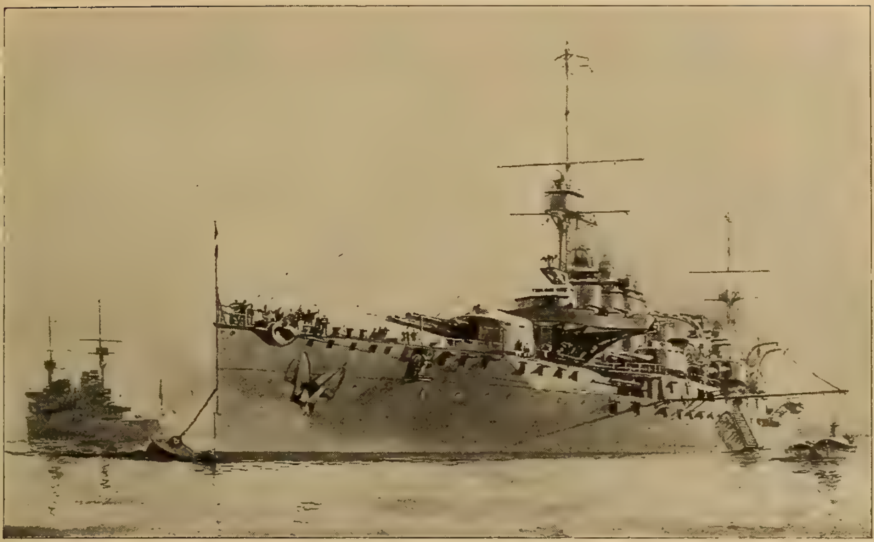
Photograph by Stephen Cribb, Southsea.

ENGLAND'S SECOND NEW DREADNOUGHT, H. M. S. BELLEROPHON

half-sisters of the *Indomitable* class. In both types of ships, as in the *Lord Nelson* and her sister, medium calibre guns were eliminated, and all the weight available for gun power was devoted to the mounting of 12-inch weapons of 45 calibres instead of 12-inch in association with 9.2-inch guns.

Almost immediately after particulars of this design became known in sufficient fullness for criticism, Rear-Admiral Mahan, the distinguished American writer, opened a vigorous attack upon it. The *Dreadnought,* thanks to the adoption of water-tube

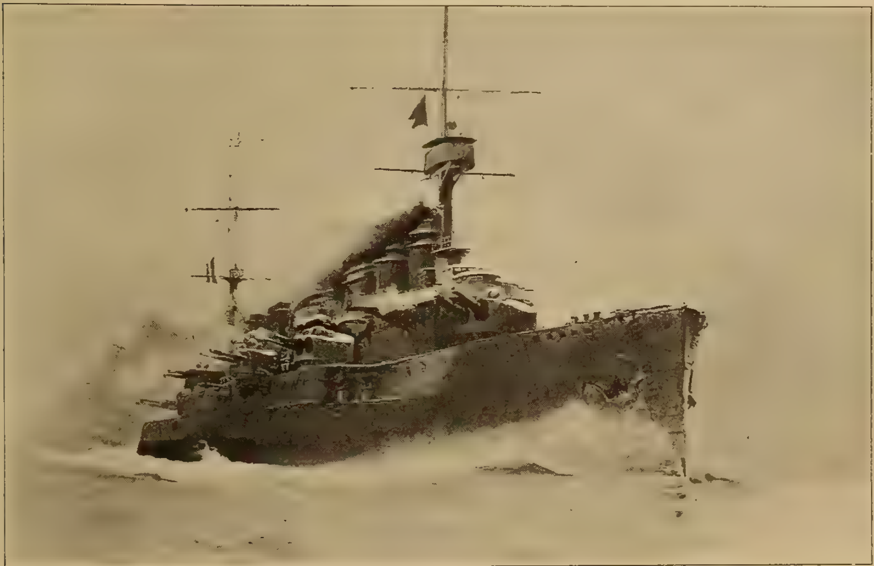
writer's opinions were based upon his own views of the conclusions to be drawn from the war in the Far East, but they were almost immediately upset by fuller details, particularly the notes of a naval constructor of the Russian fleet, which were supplied to Lieut. R. D. White, of the United States Navy, and very intelligently interpreted by him. Commander Sims immediately took up the gauntlet which Admiral Mahan had thrown down, basing his contention on the ascertained facts made public by Lieut. White. He contended that, assuming Lieut. White's account



FRENCH BATTLESHIP CONDORCET

of the battle of Shushima was correct (and it has since been corroborated in all essential details), it followed that much of the information upon which Admiral Mahan based his conclusions was in error to a greater or less degree.

Commander Sims pointed out that turrets are now for the first time being designed practically invulnerable to all but heavy projectiles. This development, in association with the heavy armoured belt above the waterline and extending from end to end which it is now possible to give to a ship of large displacement and the complete protection of the conning tower, enables all the gun-



FRENCH BATTLESHIP DANTON

nery personnel to be so protected that they cannot be materially injured by small calibre guns. By eliminating the secondary battery, consequently, the designers have been

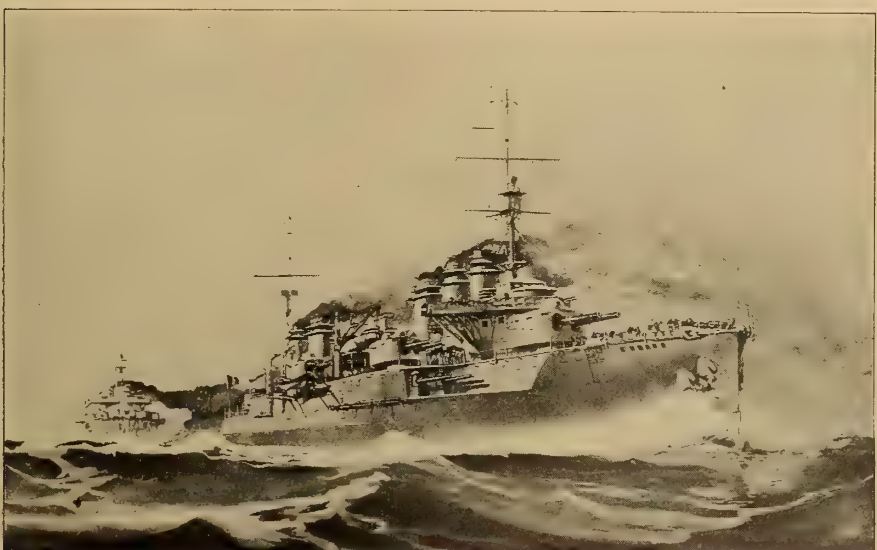
Photograph by Stephen Cribb, Southsea.

LAUNCH OF THE ST. VINCENT

able to give guns and gunners increased protection and, at the same time, mount more weapons capable of giving knock-out blows at long ranges. Commander Sims further pointed out that by the concentration of power the battle line would be shortened and the flexibility of a fleet, its ability to change its formation in the least possible time and space with safety to its units, increased. At the same time by mounting one type only of big

gun, it was possible to simplify fire control and enable the officers to obtain the maximum efficiency.

Four years only have elapsed since the first indefinite news of the design of the *Dreadnought* became known, and now seventy ships, representing in varying degrees the adoption of the all-big-gun principle, are either built, building, or about immediately to be authorized for the world's navies. Among the responsible naval authorities of the world there have been found no adherents of the medium-sized battleship. The argument that it is unwise to place too many eggs in one basket in view of the development of the power of torpedo and mine has made no converts. The belief that the costliness of the all-big-gun ship of large displacement would deter the less wealthy nations from embarking upon such construction has proved unfounded. The suggestion that the heavy capital expenditure which would be necessary in deepening harbours and channel ways and in increasing the length and breadth of dry docks in order to accommodate these colossal ships would put a brake upon naval expansion even in the richest countries has been falsified. Throughout the world the battleship of great displacement and high speed has been adopted, with the result that to-day many of the new heavily armoured, all-big-gun ships have a higher sea speed than any of the protected cruisers, under whatever flag, which were built in the late years of the last century for intelligence purposes or for the attack upon or defense of commerce. These cruisers, many of them less than ten years old, have lost their only claim to usefulness. They were built with light guns and a minimum of armour in order to enable them to develop what was then considered a high sea speed. In service they actually possessed an advantage of four to six knots over contemporary battleships. The development of the water-tube boiler and the marine turbine has relegated these cruisers to positions of great inferiority as steamers, while the appearance of the battleship-cruiser of the *Indomitable* class, of which examples are to be found now in British, German, Japanese and Italian shipyards, has com-



FRENCH BATTLESHIP DIDEROT

pletely eclipsed them in gun power and in protection. The modern battleship-cruiser allies the power of eight or more of the heaviest guns with the protection afforded to battleships of the first class as recently as ten years ago, and a speed of 25 knots, which the best protected cruisers of the immediate past never approached.

It is evident that the all-big-gun ship has come to stay, and it is already beyond dispute that the original *Dreadnought* design does not represent finality. In the British service the ten 12-inch guns of the *Dreadnought* were associated with twenty-seven 12-pounders as an anti-torpedo armament. This was a detail of design which was immediately subjected to considerable expert criticism in view of the increased size and power of resistance of modern torpedo craft. The result of reconsideration is embodied in the *Bellerophon* and *St. Vincent* classes, in which the 12-pounder gun fitted in their prototypes has been replaced by a new type of 4-inch weapon. Apart from this change and some variation in armour protection and mechanical equipment the eight vessels of the *Dreadnought* type, which are now built or building for the British fleet, broadly represent one single general design, and, when completed, will form a singularly homogeneous squadron. Associated with these eight ships in the active British fleet will be the four vessels of the *Indomitable* class. Three of these were designed at the same time as the *Dreadnought,* have a speed of 25 knots, and carry eight 12-inch guns, in association with a 7-inch armoured belt; their anti-torpedo armament consists of sixteen 4-inch guns. The fourth vessel of this class, which has recently been laid down at Portsmouth, is a considerably larger ship, but it is understood that she will mount the same number of 12-inch guns. When the British ships now actually under construction are completed in the spring of 1911, the fleet will consequently include twelve

Photograph by Stephen Cribb, Southsea.

THE DREADNOUGHT STEAMING AND CLEARED FOR ACTION. SHE IS SEEN TURNING

vessels embodying the simple and effective fire control, which is possible only in an all-big-gun ship, and in addition it will possess the *Lord Nelson* and *Agamemnon* and the eight battleships of the *King Edward VII.* type, representing the intermediate stage in the development of the battleship from the conventional type of 15,000 tons displacement. The increased gun power, the higher speed and the more adequate protection have been purchased in the twelve latest battleships and battleship-cruisers at the price of an augmentation in displacement of about 5,000 tons—equal to a percentage of 25 per cent. Since the period of the 15,000-ton battleship, the cost per unit has at the same time been practically doubled. The earlier battleship of 15,000 tons was completed for sea at a cost of about one million sterling, whereas it is estimated that the two vessels recently laid down for the British Navy will involve an expenditure of about two millions each—an increased

FRENCH BATTLESHIP MIRABEAU

outlay of about 100 per cent. At this price, apart from the development in gun power and the heavy weight of armour carried, the speed of the latest British battleships represents an advance of rather over three knots, and that of the battleship-cruisers of rather more than seven knots.

The navy which has shown most energy in adopting the all-big-gun principle is Germany. By the summer of the present year she will have under construction thirteen of these units. The significance of this activity it would be difficult to exaggerate. Prior to the appearance of the *Dreadnought* Germany had laid down no armoured ship of more than 13,000 tons. She had been satisfied with a vessel which was a natural development of the early coast-defense type, of which her navy was originally composed. She still adhered to a design in which bunker capacity and speed were sacrificed to the concentration of gun power. This policy of gun concentration found expression not in an increased number of weapons of the heaviest power, but in the secondary armament. The ten modern completed battleships of the German fleet carry only four heavy weapons, the 11-inch gun, and not the 12-inch, as in the British and United States fleets, in association with fourteen guns of 6.6 inches. Whereas in England the growth in displacement, in power and in speed was gradual, one step following another in almost inevitable sequence, in Germany the advance was dramatic and even sensational. At one step the Marine Office passed from the design of 13,000 tons to a design of approximately 18,000 tons. While hitherto Germany had been content to construct battleships considerably smaller than those of England, France and the United States, under the Act of 1906 she obtained authority from the Reichstag to lay down a series of vessels exceeding, at that time, the nominal displacement of any vessel then building either in Europe or in

Photograph by Stephen Cribb, Southsea.

UNDOCKING THE BELLEROPHON

Courtesy of Munn & Co. Copyright, 1909.

THE LATEST UNITED STATES BATTLESHIP OF THE DREADNOUGHT TYPE, HAVING 26,000 TONS DISPLACEMENT

See table, page 14, A and B type.

the United States. At the same time the German authorities determined to imitate the secrecy which had been practiced by the British Admiralty when the *Dreadnought* design was evolved. This naturally led to the circulation of wonderful stories as to the speed and gun power of the new German ships. It was at first rumoured that these ships would displace twenty to twenty-two thousand tons, whereas it is now known that the figure is approximately 18,000 tons. Originally it was also stated that each vessel would mount as many as eighteen 11-inch weapons; subsequently rumour placed it more moderately at fourteen, and there now seems no reason to doubt that the actual armament will consist of twelve of these weapons mounted, not in six double turrets resembling

THE WORLD'S DREADNOUGHTS.
Built, Building or Projected.

GREAT BRITAIN.

	Name.	Displacement.	Designed Speed.	Laid Down.
		Tons.	Knots.	
1	Dreadnought...	17,900	21	Oct.,1905.
2	Inflexible......	17,250	25	Feb. 1906.
3	Indomitable....	17,250	25	March, 1906.
4	Invincible......	17,250	25	April, 1906.
5	Bellerophon....	18,600	21	Dec., 1906.
6	Temeraire.....	18,600	21	Jan., 1907.
7	Superb........	18,600	21	Feb., 1907.
8	St. Vincent.....	19,250	21	Dec., 1907.
9	Collingwood....	19,250	21	Feb., 1908.
10	Vanguard......	19,250	21	April, 1908.
11	Neptune.......	20,250	21	Jan., 1909.
12	Indefatigable...	19,000	25	Feb., 1909.
13–18	"A" to "F"...	.....	....	Programme, 1909–10.

JAPAN.

	Name.	Displacement.	Designed Speed.	Laid Down.
1	Satsuma.......	19,250	20	May, 1905.
2	Aki..........	19,780	20.5	March, 1905.
3	Battleship "A"	20,770	20.5	Dec,. 1907.
4	Battleship "B"	20,750	20.5	Dec., 1907.
5	Ikoma.........	13,750	25	
6	Kasama.......	14,650	25	
7	Haki..........	14,650	25	
8	Cruiser "E"...	18,650	20.5	

UNITED STATES.

	Name.	Displacement.	Designed Speed.	Laid Down.
1	Michigan......	16,000	18.5	July, 1906
2	South Carolina.	16,000	18.5	July, 1906.
3	North Dakota..	20,000	21	Oct., 1907.
4	Delaware......	20,000	21	Oct., 1907.
5	Utah..........	20,000	21	Nov., 1908.
6	Florida........	20,000	21	Nov., 1908.
7–8	"A" and "B".	26,000	21	

FRANCE.

	Name.	Displacement.	Designed Speed.	Laid Down.
1	Danton........	18,027	19	Feb., 1908
2	Mirabeau......	18,027	19	April, 1908.
3	Voltaire........	18,027	19	June, 1907
4	Vergniaud.....	18,027	19	July. 1907.
5	Diderot........	18,027	19	1908.
6	Condorcet......	18,027	19	1908.

ITALY.

	Name.	Displacement.	Designed Speed.	Laid Down.
1	Mirabello......	18,302	23	June, 1908.
2	"B"..........	18,302	23	1909.

GERMANY.

	Name	Displacement	Designed Speed	Laid Down
1	Nassau........	17,679	19	July, 1907.
2	Westfalen......	17,679	19	July, 1907.
3	Rheinland.....	17,960	19	Aug., 1907.
4	E.* Baden.....	17,960	19	Aug., 1907.
5	Cruiser "F"...	18,700	25	March, 1908.
6	E.* Oldenburg.	19,000	20	Oct., 1908.
7	E.* Siegfried...	19,000	20	Oct., 1908.
8	E.* Beowulf....	19,000	20	Oct., 1908.
9	Cruiser "G"...	20,000	25	Oct., 1908.
10	E.* Frithjof,...	18,000	19	
11	E.* Hildebrand	18,000	19	
12	E.* Heimdall...	18,000	19	
13	Cruiser "H"...	18,700	25	

* Ersatz=replacement of older ship.

BRAZIL.

	Name	Displacement	Designed Speed	Laid Down
1	Minas Geraes..	19,250	21	1907.
2	San Paulo.....	19,250	21	1907.
3	Rio de Janeiro..	19,250	21	Nov., 1908.

RUSSIA.

	Name	Displacement	Designed Speed	Laid Down
1	"A"..........	20,000	21	1908 Program
2	"B"..........	20,000	21	
3	"C"..........	20,000	21	
4	"D"..........	20,000	21	

CHINA.

	Name	Displacement	Designed Speed	Laid Down
3	"A," "B" & "C"	21,000	21	It is reported that more ships will be built at an early date in Europe.

CHILI.

	Name	Displacement	Designed Speed	Laid Down
2	"A" & "B"...	19 000	21	No further details of these ships are known.

ARGENTINA.

	Name	Displacement	Designed Speed	Laid Down
3	"A," "B" & "C".	16,500	20	New naval programme.

the type adopted for many years past in the British service, but in four turrets each with three guns, these four turrets being disposed en echelon, thus giving each vessel a broadside fire of twelve pieces. The success of these ships depends upon the results obtained from this remarkable innovation—the double turret—of which no details have become known. In this connection it is sufficient to say that this disposition of armament has not commended itself to the technical advisers of other admiralties. While Great Britain has complete, or practically complete, seven *Dreadnoughts,* and three others have been launched, only four of the fourteen German ships building or authorized have yet taken the water. But the noteworthy fact in connection with German design is that in the *Dreadnought* battleships and in the three battleship-cruisers she has followed British initiative and has adopted the all-big-gun principle in all its simplicity. It has been suggested that these German ships will retain a heavy secondary armament of a dozen 6.6-inch guns, but there is reason to think that the anti-torpedo armament will be similar to that of the later British vessels and will consist of 4-inch quick-firers.

The French authorities, under the shipbuilding programme adopted in 1906, and, therefore, after the general details of the *Dreadnought* were known, have not adopted the all-big-gun principle.* These vessels may be regarded as the bigger sisters of the *Lord Nelson.* Each is to mount four 12-inch guns, in association with twelve guns of 9.4 inches, and the anti-torpedo armament will consist of sixteen 3-inch quick-firers and eight smaller guns. This design does not embody the simplicity of fire control which is obtained in the *Dreadnought* type of ship, and there is reason to think that the general design actually dates from a period prior to the appearance of the *Dreadnought* and was developed from the British *Lord Nelson* rather than from the British *Dreadnought.* It should be added that there are officers even in the British service who prefer the armament of the French vessels with sixteen mixed big guns to the *Dreadnought* design with only ten 12-inch guns, but these opinions are not as a rule held by those who are familiar with recent advance in gunnery science. A proposal was drawn up in 1908 for laying down six more battleships, which would probably have embodied the all-big-gun principle in its simplicity, but the project has been postponed owing to the exigencies of the budget. The same cause is responsible for the comparative inactivity of Italy, and latest reports indicate that Austro-Hungary will soon have under construction an even larger number of vessels representing the *Dreadnought* ideal than Italy. Great delay has also been experienced in carrying out the Russian programme, which includes the construction of four *Dreadnought* ships. The delay has been due to the pressure exerted by the Duma upon the government in the direction of reform in the naval department. There is every indication, however, that these four ships will shortly be under construction. They will embody the single-calibre gun principle, with a speed of about 21 knots, and it is stated will displace 20,000 tons.

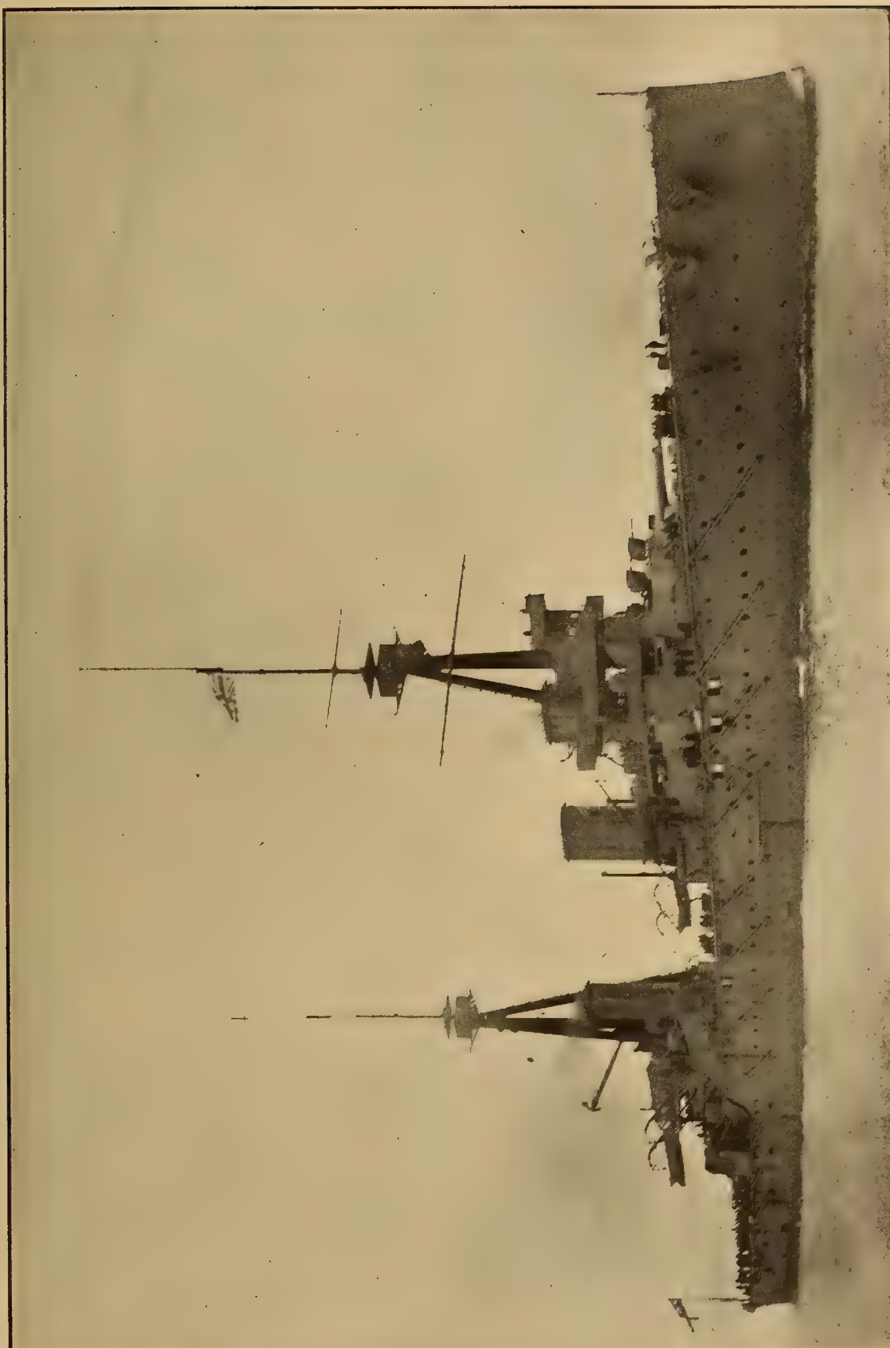
Outside Europe, the United States has been most active in the development of the big battleship. At the present moment, while England possesses built or building twenty-two battleships or battleship-cruisers of upwards of 15,000 tons, the American fleet possesses six of 16,000 tons built, two of 16,000 tons building, four of 20,000 tons also under construction, and two more authorized during the present year, which, it is understood, will displace about 26,000

* It has been stated in France that these six ships were actually designed before the *Dreadnought,* and after the ship's appearance it was determined not to change the design.

tons and will, therefore, be the largest battleships hitherto planned by any naval power. All the eight American ships built or building represent the all-big-gun principle. The pieces. These two ships will have a design speed of 18½ knots, with an armour plate ranging in thickness from 9 to 11 inches. The four succeeding ships represent an advance

FRENCH BATTLESHIP VERGNIAUD

two earliest vessels of the type, the *Michigan* and *South Carolina*, displace 16,000 tons and carry an armament of eight 12-inch guns, in association with twenty-two 14-pounder quick-firers and sixteen smaller of 25 per cent. in displacement and are to be of 20,000 tons. This increased tonnage has been equally distributed between speed, protection and gun power. Their speed will be 21 knots, the armour plate will

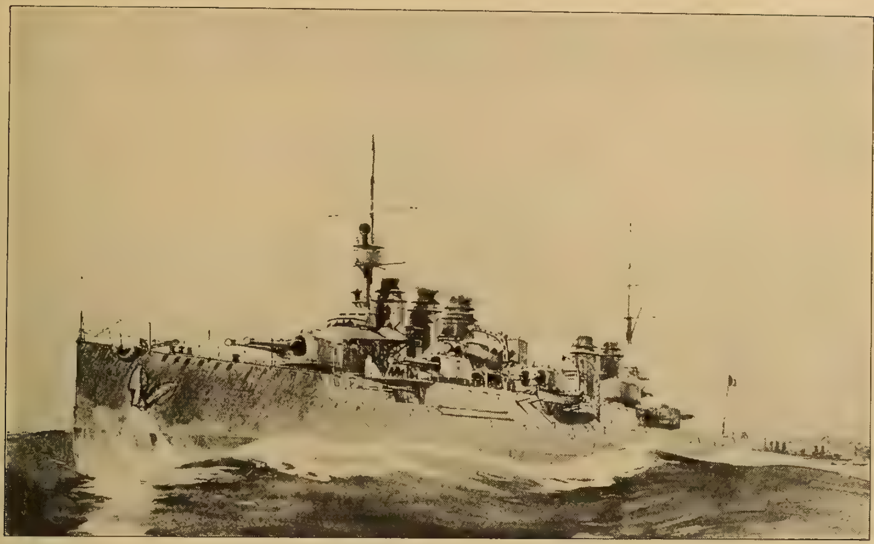


Photograph by Stephen Cribb, Southsea.

THE MYSTERY SHIP H. M. S. INFLEXIBLE. SHE IS THE FASTEST AND MOST HEAVILY-ARMED CRUISER AFLOAT

be 11 inches thick, and each will carry ten 12-inch guns, with fourteen quick-firers of 5 inches, and two smaller weapons. In spite of Rear-Admiral Mahan's criticisms, the American Navy is traversing the path pointed out by the British authorities, with little deviation to one side or to the other, and are thus also emulating the example set by Germany. In view of the criticism of the *Dreadnought* design by Sir William White, Rear-Admiral Mahan and a few uninfluential writers, it is a significant fact that the three leading naval powers, to say nothing of Russia, have adopted the all-big-gun principle, a high rate of steaming, heavy protection, even at the disadvantage of greatly augmented displacement. This movement has progressed in direct antagonism to the arguments put forward by the advocates of medium battleships, who have urged the unwisdom of putting too many eggs in one basket.

In Japan the development of the *Dreadnought* design has been followed with less consistency than in Europe and in America. Before hostilities with Russia occurred, Japan had ordered in England two vessels very similar in type to the British *King Edward VII.* These ships, the *Katori* and *Kashimi,* were laid down early in 1904. Each is provided with four 12-inch guns, four weapons of 10 inches, and twelve 6-inch quick-firers. The speed on trial of the Barrow-built ship was 20.22 knots, while the Kashimi, built by the Armstrong firm, of somewhat larger displacement, was 19.24 knots. It may be added that Messrs. Vickers Son & Maxim were responsible for the engines of the *Katori,* while Messrs. Humphrys, Tennant & Co. made the engines of the *Kashimi.* Both ships have twenty Niclausse boilers. These ships were not completed in time for the war. Before the battle of Shishima, the Japanese naval authorities had determined to embark on the construction of their own armoured vessels instead of depending upon European yards. In the first six months of 1905 they laid down two new battleships, the *Aki* at Kure, of 19,800 tons and 20½ knots speed, and the *Satsuma* at Yokosuka, of 20 knots speed. These two vessels differ in many details of design, but carry a similar armament. Each mount four 12-inch guns and a dozen weapons of the 10-inch type, with a similar number of 6-inch quick-firers and eight smaller pieces. In armament these vessels resemble the *Katori* and *Kashuma,* with the addition of twelve 10-inch guns, and are entirely unlike any of the new ships hitherto designed for other navies. They indicate apparently a state of indecision on the part of the Japanese between the relative advantages of the *Lord Nelson* and *Dreadnought* and *Indomitable* types. It has been suggested that the Japanese experts were themselves in some doubt as to the lessons applicable to armament, which could safely be drawn from their experiences during the war. It is beyond dispute that hitherto the Japanese have not had the advantage of the fire-control system adopted with slight variations by Great Britain and the United States, a system which has been mainly responsible for the somewhat close similarity in design of the recent ships authorized in both countries. Since these two latest Japanese battleships were laid down, officers of this fleet have had the advantage of studying, in some detail, the fire-control system of the British and American fleets, and the result may be traced in the reputed design of the two battleships of nearly 21,000 tons which have lately been laid down, one at Kure and one at Yokosuka. These two ships, it is stated, represent Japan moving into line with naval opinion in Great Britain, the United States, Germany and Russia. The main armament will consist of a dozen 12-inch guns, but the anti-torpedo armament, instead of comprising 4-inch quick-firers, will, it is reported, consist of



FRENCH BATTLESHIP VOLTAIRE

a dozen 6-inch weapons, with only eight smaller pieces.

With reference to the remainder of the seventy *Dreadnoughts* which are now being constructed for the various fleets of the world, it is only necessary to mention specifically the three battleships which the Brazilian Government have already ordered in England.

Two of these ships are already in an advanced stage of construction, and the other will be laid down at an early date. A model showing this design was exhibited at the Franco-British exhibition in London last summer. These three ships, each of which will have a displacement of 19,250 tons, a speed of 21 knots, armour plates with a maximum thickness of 9 inches, and an armament of twelve 12-inch guns carried in double turrets, so as to give a broadside fire of ten guns and an end-on fire of eight. The anti-torpedo armament comprises twenty-two 4.7-inch guns and eight 3-pounders. The three battleships which are projected in Argentina are to be similar to the *Lord Nelson*, while, if the armament scheme reported from Chili is persevered with, the total number of *Dreadnoughts* built and building will be increased to sixty-two. According to this report, Chili is about to lay down two vessels of 19,000 tons, provided with a main armament of ten 12-inch guns, in association with sixteen guns of 4.7 inches.

BARRIERS TO INTERNATIONAL TRADE

A STUDY OF THE PROBLEMS AT THE PORTS OF LIVERPOOL AND NEW YORK

By Lewis M. Haupt, C. E.

In the March issue of this magazine Professor Haupt discussed the important influence exerted upon the limitations of navigation and shipbuilding by the obstructions in the principal seaports, taking as especial examples the bars in the harbours of Liverpool and New York.

The first article treated of the port of Liverpool, and the subject is completed by the present examination of the bar in the harbour of New York, and the methods, existing and proposed, for the maintenance of a deep channel for transatlantic liners.—The Editor.

II.—THE BAR IN NEW YORK HARBOUR

THE keen competition for inter-oceanic traffic has led the White Star Line to place contracts at Belfast, Ireland, for the construction of two of the largest steamers ever built, to be known as the *Titanic* and *Olympic,* to outrank the huge Cunarders, the *Mauretania* and *Lusitania,* which have broken the speed record of the world, the former having made her eastern passage in 4 days 20 hours, or at the rate of 25.2 knots per hour, and her western passage in 4 days 17 hours 50 minutes. The new vessels will have a length approximating 900 feet and a beam of 90 feet, but will be built for capacity rather than speed. It is evident, therefore, that the curve of the evolution of the ocean greyhounds, as set forth in the December issue of Cassier's Magazine, was well within the possibilities of the immediate present, and it follows that the increase in the capacity of the channels across the bars which obstruct our ports must keep pace with this growth of the vessel, or the ports must surrender to those in more favourable locations.

Attention has frequently been called to the question of the New York bar, and in view of the detentions for fovorable tides it still remains a live issue in the interchange of international commerce.

PHYSICAL FEATURES OF THE BAR

Between Sandy Hook and Coney Island there is an open stretch of seven miles of water, in which, to the uninitiated, it would seem practicable to navigate in any direction; but a glance at the chart will reveal the intricate ramifications of shoals and channels which lie hidden under the surface, with depths ranging from 3 to 23 feet in their natural state, and which, after careful surveys, have been located and buoyed to render them safe. For more than sixty years these examinations have been made to note the changes which are taking place, in order that the best methods may be applied to the improvements so necessary to meet the demands of the port. From the survey of 1886 a small model has been made to illustrate the mould of the bottom of the lower bay and the resultant effect of all the forces operating to maintain these barriers.

In 1857 the Coast Survey Report thus describes these channels: "The Main Ship Channel is next north of Sandy Hook. It is 1,050 yards wide, and the passages from it through the outer bar are by Gedney's Channel, with its 23½ feet, and by the South Channel, with 23 feet M. L. W. North of this is Flynn's Knoll, covering an area within the 18-foot curve of 852 acres. Northeast of

87141

this is the Swash Channel * * * with an average width of 900 yards, and through it 21 feet can be carried. Northwest is the Romer Shoal (3 feet), and northeast of this shoal is the East (now 'Ambrose') Channel, 750 yards in width, with 19 feet of water, from which a remarkable 'slue' extends to Gedney's Channel.* Next comes the Middle Ground Shoal, covering 1,548 acres, followed by the Fourteen-Foot Channel, closed by a wide bar, with 14½ feet upon it. Then the extensive East Bank, covering 3,063 acres. Finally, the slue close to Long Island shore. This entire bank is of sand similar to that of the beaches of New Jersey and Long Island, the river deposits taking place higher up the bay."

Reciprocally, the antics of the flood and ebb currents which have caused these irregularities in the deposits may be seen from the chart, which indicates the resultant intensity and direction of the movements at the surface, as well as its depths of 2 and 4 fathoms. Following the Main Ship Channel down from the Narrows, it is seen that the current sets first to the eastward of south, then swings to the westward, and again turns sharply to the east in Sandy Hook Bay, where it is diverted to the north along the inner shore of the Hook. On passing the point it sets northeast towards the "slue" and, just over the crest of the bar, swings again to the east and southeast, thus clearly indicating the controlling influence of the deposits of sand driven up by the external littoral forces of the flood tide which have built out the peninsulas of Sandy Hook from the New Jersey coast and Coney Island from Long Island. Numerous important conclusions are deducible from these recorded facts; but suffice it to state that the localities of least scour are not always those of least action, since the opposing forces may be so nearly equal as to neutralize one another's effects in removing material. For example, there are depths of only 3 feet on the crest of the bar subject to high velocities, while in the Narrows the depth reaches a maximum of 116 feet under a lower mean velocity. So, too, at the end of the Hook the depth is from 55 to 66 feet, due to the *reaction* of that obstacle to the passage of the currents, and not to mere velocity. The existence of the Sandy Hook spit is largely responsible for the unusual natural depths of 23 and 24 feet in these southerly bar-crossings at Gedney's and South Channels. By the concentration of these currents into one, a much better channel may be secured, if the crossing be protected from the northwardly-moving drift. This is one of the points where the good offices of Nature may be aided to permanently improve the navigation. Another is to be found directly under the lee of Coney Island, where the flood tide tends to cut a channel in its effort to enter the bay, and where the bar drops off suddenly on its inner slope, indicating the direction of the movement of the sand from Long Island.

The sinuous line on the model representing the crest of the bar is important as illustrating the location of greatest activity of both the flood and ebb currents in moulding the bar channels. At the north end of the "Axis of the Entrance" the flood tide has driven the crest line inside of this axis, while at the south end the ebb tide has a much greater effect in the opposite direction. The successful enlargement of these channels must utilize these factors.

THE MENACE FROM THE JAMAICA BAY BAR*

No improvement of the New York entrance can long remain open unless early attention be given to the large volume of sand which is rapidly

* See Harbour Studies—The New York Entrance; by the author, Engineers' Club of Philadelphia, 1886.

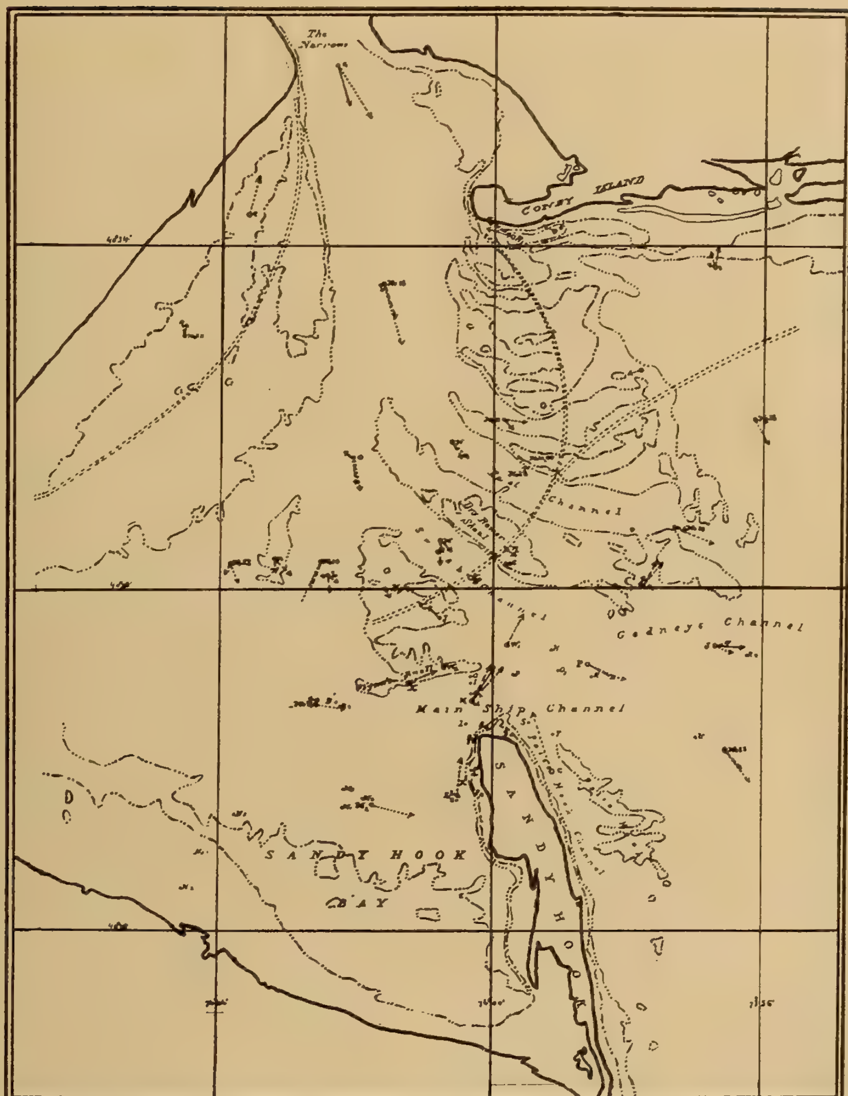
* See "A Menace to the New York Harbour Entrance," Franklin Institute Journal, February, 1905.

being driven directly in to the Ambrose Channel from the shores of Long Island. Here the former depository for this drift, which was in Jamaica Bay, has been virtually closed for more than sixty years, and the sands are traveling to the southwest at the present rate of one mile in 17.6 years. The deposit outside of the bay contains some 65,000,000 cubic yards, while the annual accretions from the shore drift is about 1,000,000 more, and the rate of its advance is increasing. The progress

MODEL OF THE LOWER BAY OF NEW YORK, SHOWING PROPOSED IMPROVEMENT OF THE NEW YORK BAR BY THE REACTION BREAKWATER

made since 1835 is shown on the comparative chart, which indicates the advance of the spit to be nearly 3½ miles in seventy-one years, or 240 feet per annum.* During the last eighteen years the rate of advance has increased to 300 feet per annum, and as the depths grow less this rate must increase and the deposit spread, thus closing the access to the upper portion of the entrance and changing materially the regimen of the harbor. So rapid is this action that depths of more than 50 feet at the point of the spit five years ago are now fast land, rising above the tides, and the lands on the northerly side of the channel have disappeared, nearly all of Pelican Island having been eaten away by the action of this advancing sandy spit.

Although this problem has been under consideration by the government for more than thirty years, and it has been reported that "An attempt to arrest this movement by artificial works would be successful only after enormous expenditures, and would inevitably result in the obliteration of the inlet itself," the writer begs to dissent from these conclusions, and believes that, with the tidal energy exceeding 4,500,000 foot-pounds per second, or 8,400 horse-power available, it may be economically applied to the creation of a self-maintaining channel, which will be readily navigable for the largest vessels from the ocean, and that the drift may likewise be fully controlled by suitable impounding



NEW YORK HARBOUR. CURRENTS IN THE LOWER BAY

Surface resultants are shown by dotted arrows; 12-foot depth resultants by broken arrows, and 24-foot depth resultants by full arrows. The length of the arrow in each case measures the scouring force at the stations marked thus: O.

works which will pay for themselves in the lands reclaimed.*

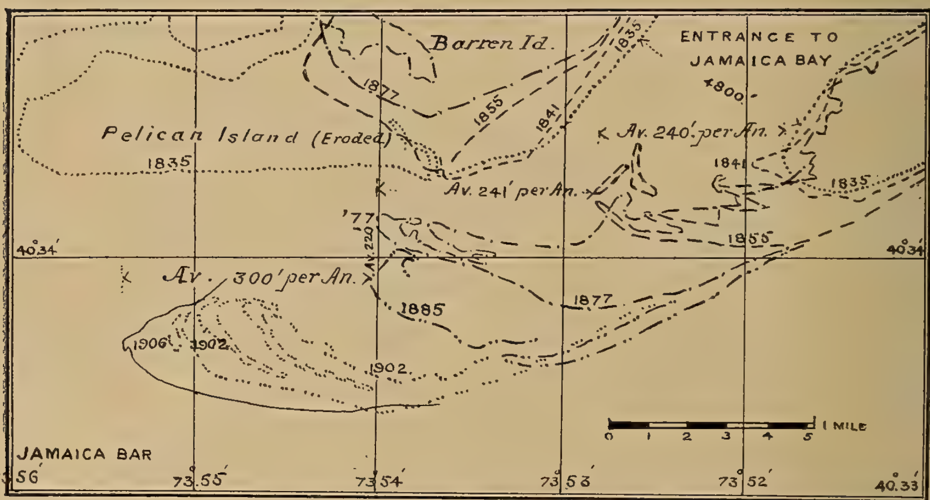
THE PRESENT PROBLEM

That considerable progress has been made in maritime methods may be seen from the statement as to the conditions prevailing as early as 1829, when it was proposed to deepen the bar at Roanoke Inlet, N. C., under an act of Congress dated May 20, 1826, whereon it was reported that "It is impossible to enter upon the discussion of the proposed project * * * * without feeling deeply sen-

* See address before the New York State Waterway Convention, Jan. 21, 1909, in "New York Manufacturer," March issue.

sible of the difficulties in effecting so desirable an object and the degree of uncertainty attending the result of any operations where the causes to be governed are so infinite and powerful. Wherever the course of Nature in her marine operations is to be governed, there is probably no subject within the range of the sciences where so much is deduced from hypothesis, and where, necessarily, in the result there is so little certainty."

Sixty years later, when the growth of the vessels had demanded the enlargement of the channels of the principal ports, it would seem that considerable uncertainty still existed, for in the plans proposed for the improvement of the New York bar in 1884 and subsequently it was reported by a board of United States engineers that, by building a dike from Coney Island towards Gedney's Channel about 5 miles long the water cross-section would be reduced from 790,000 square feet to 470,000, and the mean velocity would be nearly doubled; but "it is not thought that so great a contraction will be necessary to give 30 feet. It is impossible to predict precisely what contraction will be necessary, but there is little doubt that this depth can be maintained. * * * In building such a dike it should at first certainly not be brought above low water, and perhaps not so high. While being lengthened its effects should be carefully watched, any important reduction in the tidal prism inside being avoided by allowing the new channels to fully develop, aiding them by dredging, if necessary; and the dikes should be carried no further than may be found by experience to be required."



COMPARATIVE CHART, SHOWING GROWTH OF THE OUTER SPIT COVERING JAMAICA BAY, BETWEEN 1835 AND 1906

Average rate in the 71 years is 240 feet. In the last 18 years it is 300 feet per annum, or one mile in 17.6 years.

In addition, the Board reported on its plan of a jetty extending from Sandy Hook to the southerly side of Gedney's Channel, 2½ miles long; and while admitting that it might deepen the channel, they objected to it lest "the result might be to open the East Channel, the Fourteen-Foot Channel or the Coney Island Channel. As it is important that but one channel should exist over the bar, if deep water is to be maintained there, such a result would be very unfavourable." The conclusion was reached in favour of the Coney Island

dike, estimated to cost between \$5,000,000 or \$6,000,000, with the suggestion that "should changes in channels or other results in the progress of the work indicate the advisability of any portion of such dike from Sandy Hook, it might then be constructed."

This uncertain and tentative report, which proposed to close most of the channels crossing the bar by a dangerous, submerged structure and reduce the tidal influx materially, requiring extensive dredging to maintain the interior channels of the harbour, was vigorously opposed by the commercial bodies of the port, and in an address to the Secretary of War, dated November 4, 1886, Mr. A. Foster Higgins has so clearly set forth the conditions required that a brief extract from his communication is inserted, as follows:

"*First,* that no plan should be entertained which has for a possible result the destruction, or even increased obstruction, of any existing channel now largely used by vessels of any class.

"*Second,* that the plan and channel which should be selected as the one by which the greater draught of water is to be afforded should be the one which will most nearly approach the following standard in all particulars:

"(a) It should be the one in which 30 feet of water and a width of not less than 500 feet can be obtained at the least guaranteed cost.

"(b) It should be guaranteed, or so assured by well-known natural conditions and laws in actual operations, as not to require guarantee that it will be practically *self-maintaining* after once being constructed, and not require large annual appropriations to maintain it.

"(c) It should be contracted for in most positive terms, that neither in the process of the work nor in the results of the plan adopted shall any interference with the free and constant use of any other channels be made at any time during its prosecution or after its accomplishment.

"(d) It should be that plan which can be most speedily and certainly accomplished.

"(e) It should be the most direct and shortest route, and capable of being so lighted as to permit entrance at all hours of the night."

This protest, which was unanimously endorsed by the Chamber of Commerce, resulted in the appropriation for dredging of the Main Ship and Gedney's Channels and the abolition of all permanent regulating works.

This agitation led to the presentation of some eleven plans by those interested in the relief of the port and the request for a mixed commission of experts to consider and report some definite project; but this was opposed by the government, and dredging has been relied upon ever since to create and maintain the 30-foot channel at a heavy annual charge.

DREDGING OPERATIONS

Prior to the survey of August, 1884, Congress made an appropriation on July 5, of \$200,000 for the dredging of Gedney's and the Main Ship Channels. The project was estimated to cost for Gedney's Channel, 30 feet deep and 1,000 feet wide,

700,000 cubic yards, at 50 cents	\$350,000
Main channel, 1,550,000 cubic yards, at 40 cents	620,000
Total	\$970,000

This survey and project were referred to the Board of Engineers, which reported, as above stated, December 23, and on the 26th the Chief of Engineers approved it, with the following extracts from the report of the Board: "While not expecting large results from dredging here yet, as the appropriation is specifically confined to this channel, the Board recommends that an attempt be made to secure a channel there 28 feet deep and of such width as the appropriation will pay for by one of the numerous methods of dredging.

"If, before the whole appropriation

were expended, experience should show that the dredged channel rapidly filled up, the work might be stopped by the Secretary of War,

SOUTHWEST PASS OF THE MISSISSIPPI RIVER, SHOWING LOCATION OF JETTIES PROPOSED BY BOARD OF ENGINEERS OF 1899. THE DOUBLE DOTTED LINES SHOW THE REACTION JETTY PROPOSED FOR IMPROVEMENT

the contractor being properly remunerated."

Again, the Board had "little expectation that anything more than temporary relief could be obtained from dredging on a bar exposed to the full force of the Atlantic, and hence cannot recommend that method for a permanent improvement."

This conservative finding of the Board of Engineers would seem to be substantially confirmed by the experience of the past twenty-four years, since the latest published report of 1908 states that for this channel, 30 feet deep by 1,000 feet wide from the Narrows to deep water outside the bar, the "estimated cost was $1,490,000 for dredging 4,300,000 cubic yards. The actual amount dredged to October, 1891, when the work was approximately completed, was 4,875,079 cubic yards. The existing project for maintenance of channels was approved November 15, 1892. The cost of this work varies in different years; it is estimated as averaging about $80,000 annually.

"Under these projects the amount expended up to June 30, 1908, is $2,146,335.03." The depths "have been maintained as nearly as possible the full width. * * * A full depth of 30 feet is maintained in the middle of the Main Ship Channel for a width of 600 to 800 feet. During the year 351,139 cubic yards were removed from the west side of this channel."

Comparing the estimates of 1884 and 1886, it is found that the cost had increased 50 per cent. and the quantity 91 per cent.; and comparing the results of 1908 with the estimate of 1886, it was shown that by October, 1891, before the work was quite completed, the excavation had exceeded the estimate by 11 per cent.; and up to date, inclusive of maintenance, the cost had increased some 44 per cent. The average cost of $80,000 for maintenance, if capitalized at 4 per cent., would represent $2,000,000 for permanent regulating works.

The Main Ship and Gedney's

Channels are manifestly not self-maintaining, and are not yet of full width throughout.

This, with the increase in the dimensions of the vessels, made it necessary to finally consider the creation of a better and shorter course to sea by way of the East Channel. The difficulties attending this movement are, briefly, as follows:

THE AMBROSE, FORMERLY "EAST," CHANNEL

In the early nineties the late Mr. John W. Ambrose appealed to Congress to open this channel for deep-draught vessels, and, after many rebuffs, the late Hon. Amos. Cummings introduced a bill, on January 18, 1897, for a channel 40 feet deep and 1,000 feet wide; but it was not considered for nearly two years, when a large delegation of prominent citizens was heard in its behalf, December 22, 1898, when seventeen speakers urged a channel 2,000 feet in width, but it was refused by the House Committee.

Mr. Ambrose, nothing daunted, went to the Committee on Commerce of the Senate and it was allowed, so that only after nine years of importunity and four successive denials by the House Committee was this important avenue of approach to the largest harbour of the United States approved and the work authorized. As to the project and results to date, the official report of 1908 states: "It involves excavation of about 42,500,000 cubic yards of material for a length of 7 miles of channel. It was authorized to be done at a cost not exceeding $4,000,000."

This would make the average cost per yard 9.4 cents for open bar work. "Under act of March 3, 1903, two U. S. dredges were built to supplement the contract work, which was far behind the required rates. In October, 1906, the contractor abandoned the work, and the River and Harbor Act of 1907 authorized the building of two more U. S. dredges and changed the authorized limit of completion to $5,148,510. * * * To July 1, 1908, $3,360,379.06 had been expended under this project in building four dredges and in excavating 32,124,442 cubic yards of sand, mud and stones. * * * During the fiscal year ending June 30, 1908, two U. S. dredges were continuously engaged upon the work, excavating 5,362,376 cubic yards of mud and sand."

"The project is regarded as about 62 per cent. completed."

From these data it appears that the total volume to be excavated would aggregate some 52,000,000 cubic yards, or 9,500,000 more than the estimate; and as the work has been under way less than nine years, it would indicate an increment of about 1,000,000 yards a year. Also, at the former average rate per yard this amount should not cost more than $4,870,478; but as the former contractors found it impossible to compete with the four U. S. dredges, they finally surrendered the contract to the government, which reported that on June 30, 1908, the channel had a continuous depth of 35 feet, with a width of 700 feet or over, and through three-fourths of its length it has already a depth of 40 feet.

"The first of the large ships to pass through the Ambrose Channel was the *Caronia* outward bound, August 27, 1907, draft at pier 30 feet 3 inches. The first to enter was the *Lusitania*, September 13, 1907, draft outside the bar 32 feet. It may be assumed that both of these ships would draw at least 2 feet more water under way." Night navigation is not used at present, and the use of the channel is also limited to ships of more than 29 feet draft and not less than 600 feet length.

The reported cost of dredging by the U. S. dredges during the year was at the rate of 4.327 cents per yard for the 5,362,736 cubic yards removed. The average cost from the beginning, as above, is found to be 10.46 cents. There are no permanent training works to regulate

the movements of the tidal currents or to defend the channel from the littoral, sand drift in the present project of the government.

THE CONEY ISLAND CHANNEL

The large amount of coastwise traffic and the narrowness of the Main Ship Channel, with its foreign commerce and greater length, made it desirable to attempt the opening of the flood-tide channel lying under the lee of Coney Island, with its ruling depth of about 15 feet, close to the western end of the island. Recently a second shoal has been building up to the eastward, rendering the opening of this entrance more uncertain.

The official reports state that "A channel 500 to 560 feet wide and 14 feet deep was dredged in 1900, and in 1905 this channel was redredged to a width of 400 feet. When surveyed in 1906, the least depth on the western of two bars in the channel was about 12½ feet and on the eastern about 16 feet." Under the first contract 38,460 yards were removed, and under the second, which was narrower, 21,649 yards were taken out, or very nearly the same amount as at first, width being considered; but it is not known how soon after the opening this cut filled up. As the quantity was small, the unit price was 36 cents per yard.

The present project "provides for dredging a channel 20 feet deep and 600 feet wide, at an estimated cost of $168,300, and $20,000 annually for maintenance." The estimated excavation amounts to 510,000 cubic yards, and the average cost is 33 cents per yard. Up to June 30, 1908, $28,165.64 had been expended and about 16 per cent. had been completed, resulting in a channel through the western bar 240 feet wide.

MOUTH OF THE COLUMBIA RIVER, SHOWING LOCATION OF REACTION BREAKWATER AND PROPOSED CHANNEL

"No estimate is submitted for maintenance, as a recent survey strongly indicates that much of the channel dredged last fall has shoaled greatly. The indications are that the actual cost of maintenance may be as much as $50,000 or $60,000, one-third or more of the estimated cost of dredging. The maximum draft that could be carried over the shoalest part of the channel is estimated at 12½ feet. The mean range of the tide is 4.6 feet. The total length of the projected channel is about 1⅛ miles."

From the above statements it appears that the channel would fill in

MODEL OF THE BOCA DE CENIZA, MAGDALENA RIVER, COLOMBIA, S. A., SHOWING THE APPLICATION OF THE REACTION JETTY TO BAR REMOVAL

about three years unless some measures be taken to protect the cut from the drifting sands and the flood currents be applied to maintain a deeper crossing by regulating works. Yet so important is this passage that it is recommended for improvement without these auxiliary aids.

ROCKAWAY INLET TO JAMAICA BAY

In reporting on the opening of this inlet to Jamaica Bay, the officer in charge of the district submits three estimates for separate channels, designated as A, B, and C, which are, respectively: for A, with dimensions 600 feet wide and 20 deep, it would require the excavation of 1,856,000 cubic yards, scow measurement, which, at 35 cents, amounts to $649,600. For channel B, the cost would be $459,200, and for C, $144,200. For maintenance, 30 per cent. is allowed, and in consequence it is concluded, "While the commercial importance of Jamaica Bay * * * would be sufficient to justify a large expenditure in providing a suitable entrance were the conditions at all favorable, under the circumstances I do not recommend the dredging of a channel as specified in the act, on account of its great original cost and the cost of maintenance thereafter, and because the opening of a westerly channel would most likely lead to a more rapid advance of Rockaway Point than obtains at present."

In this view of the situation the Board of Engineers concurs, and concluded that "It is not advisable at this time for the United States to undertake the improvement of Rockaway Inlet."

As all of the three proposed cuts open out to the westward and cross the extensive shifting banks ejected from the channel by the advancing spit, the conclusions reached are sound, and it would be unwise to hasten the growth of this deposit and the early closure of the Ambrose Channel if this course were pursued. But to do nothing and trust to Nature to provide the remedy is likewise fatal in the end, and hence the necessity of some definite and effective measures to be applied at an early date, not only for the great possibilities of these twenty-eight square miles for manufactures and commerce, but for the protection of the channel which is being excavated at so great cost to enable New York City and State to retain communications with the traffic of the world.

A PROPOSED REMEDY

Notwithstanding the wonderful advances and improvements recently made in the efficiency of hydraulic dredges, it seems surprising that so little attention has been devoted to the application of the enormous energy contained in the tidal movements so to modify them, locally, as to cause them to create their own channels across the obstructing bars.

When Nature so clearly points the way to the student, and has shown in this very instance her possibilities to produce depths exceeding 60 and even 100 feet under certain conditions of reaction, it should seem perfectly rational to utilize these forces by suitably placed regulating works, which must develop their latent energy and render it kinetic at the point where it is needed, and at the same time to protect the channel from the encroachments of the sands.

A simple and effective application of the ebb tide to the automatic creation and maintenance of the navigable Ambrose Channel is shown by the rip-rap stone training wall marked "reaction breakwater" on the model. This structure, six miles in length, could have been put in place in less than four years at a cost of about $2,500,000, and would close no channels nor interrupt in any way the free ingress of the flood tide, while it would entrain the ebb currents in their passage seaward, and not only prevent deposits, but cause erosion and create a counterscarp on the convex side of the channel, thus aiding in its protection.

This is no mere theory, as it has been actually demonstrated in numerous places under adverse conditions, and is approved by the highest authorities in the world. The problem of controlling the movements of the Jamaica bar and of opening Rockaway Inlet are also believed to be readily resolvable so soon as the commercial interests of the nation may realize their necessity.

THE MANUFACTURE OF HIGH-SPEED STEEL

By O. M. Becker

THE BARIUM CHLORIDE HARDENING PROCESS

This is the fourth article on the subject of the practical use of high-speed steel by Mr. Becker. The first one of this series appeared in August, and described the manufacture of the steel; the second article was published in December, and treated of the forging of the tools; while the February number described the practical application of the high-heat treatment to the hardening of the high-speed tools.—The Editor.

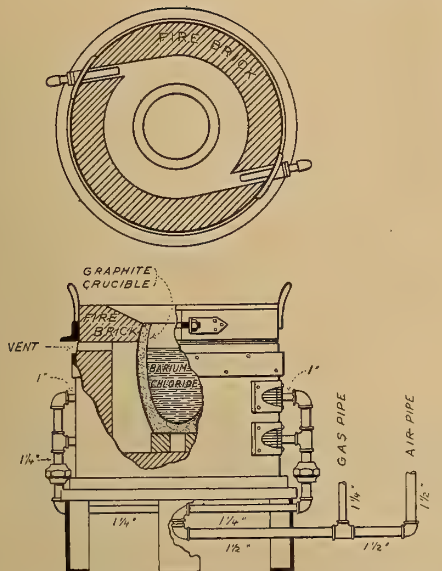
THE scaling or oxidizing of fine tools has been already referred to as troublesome in certain cases; and ways have been pointed out by which this annoyance, and the attendant expense of refinishing, could be minimized with such appliances as might reasonably be expected to form part of a moderately well-equipped hardening plant. Before the days of high-speed steel, even, it was felt that there should be some means of entirely obviating the nuisance; and many methods have been devised to that end, a number of them entirely successful except for one thing. The coke furnace, the well-regulated gas furnace, and possibly other ordinary furnaces give, as already remarked, very satisfactory results except as to tools requiring a fine finish; and the crucible furnace, in which the tool is heated in a white hot crucible, which, in turn, is heated preferably by gas or oil, entirely prevents oxidation during the heating process. So also do the lead bath and the pack hardening method. But none of these methods take cognizance of the fact that even though a tool may come out of the furnace absolutely undamaged by oxidation, the moment it is removed and strikes the air it is immediately attacked and oxidation takes place to a greater or less extent, according as the exposure to the air, prior to cooling to the normal temperature, is long or short. To overcome the difficulty entirely, it would appear to be necessary to quench tools of the kind indicated without bringing them into the air at all. This it has been impossible to do with the appliances in general use, until the recent discovery and practical development of the barium chloride process.

There are, of course, other reasons for the use of a bath in hardening fine tools. One of the most important is the need for absolute control of the temperature to within a very few degrees, and absolute uniformity in heating through every projection and into every recess in the case of intricate tools, especially when small. While ordinary furnaces, such as have been recommended, are in general very reliable, and their temperatures under sufficiently close control for most purposes, there are, nevertheless, some fluctuations occasioned by variations in pressure of the gas supply or of the air pressure, and in the size of the door and other openings during the heating. These fluctuations are insufficient in the case of large tools, generally speaking, to be harmful, because of the comparatively long time required to bring such a tool to the required heat, even when introduced into the heating chamber after being pre-heated. The small tool, because of its little mass and consequently the short time required for heating, is liable to receive a heat sufficiently different from that intended to affect its quality to a considerable extent. Furthermore, in spite of frequent turnings and other precautions, some parts of tools, complicated in shape, will heat faster

than others by their closer proximity to the incandescent walls of the heating chamber, or because of the direction of the currents which circulate in it. This is, of course, of less consequence in large tools than in small or fine ones with delicate projections or keen edges.

Another difficulty, the remedy for which in the case of certain classes of tools has been already pointed out, is that of warping while being hardened. Slender tools (like drills, reamers, and the like) of a size sufficiently large to admit of being thus heated, are not subject to this difficulty when treated in a cylindrical furnace. But small tools of necessity require a different method. The distortion is entirely avoided when the heating is done in a suitable bath. Lead, because of its high specific gravity, is not so well adapted for this purpose as certain others. The tendency is for tools to float to the surface and thus be irregularly heated, unless held down by some means. The lead bath, while it has been successfully used for hardening high-speed steel tools, is held at the extremely high temperature required with some difficulty. It rapidly vol-

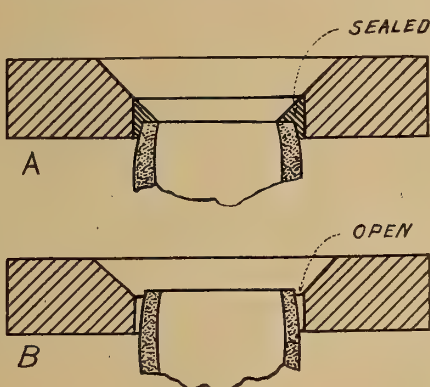
A CYLINDRICAL GAS FURNACE AS FITTED FOR USE WITH THE BARIUM CHLORIDE PROCESS. CRUCIBLE FILLED WITH MELTED SALTS. AMERICAN GAS FURNACE CO., NEW YORK, N. Y.



CYLINDRICAL GAS-FIRED FURNACE AND CRUCIBLE FOR USE IN HARDENING BY THE BARIUM CHLORIDE PROCESS. AMERICAN GAS FURNACE CO.

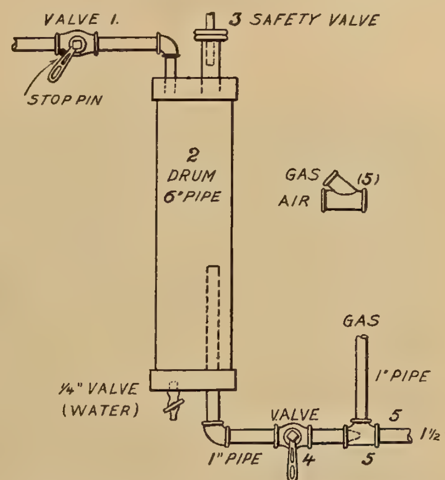
atilizes, giving off offensive and irritatingly poisonous fumes. These can, however, be conducted away so as to do little harm if provision be made, as already shown, for effectively exhausting from a properly designed hood.

There are other disadvantages in using the lead bath at these high temperatures, and indeed some disadvantages at any temperature. At a white heat the lead oxidizes rapidly,



FITTING OF CRUCIBLE INTO FURNACE TOP. LEAVING THE JOINT UNSEALED, AS IN *B*, IS THE PREFERABLE METHOD

and even when the surface of the bath is protected by a thick covering of powdered charcoal, more or less of this takes place. the scum rising and floating upon the surface of the lead. A much more troublesome thing is the sticking of the lead to the surface of tools and the consequent uneven hardness that results from the parts so covered cooling at a rate slightly different from the



REDUCER APPARATUS FOR USE WHERE AIR IS DELIVERED AT A PRESSURE HIGHER THAN 1½ OR 2 POUNDS. NECESSARY WHEN USING COMPRESSED AIR IN GAS FURNACE

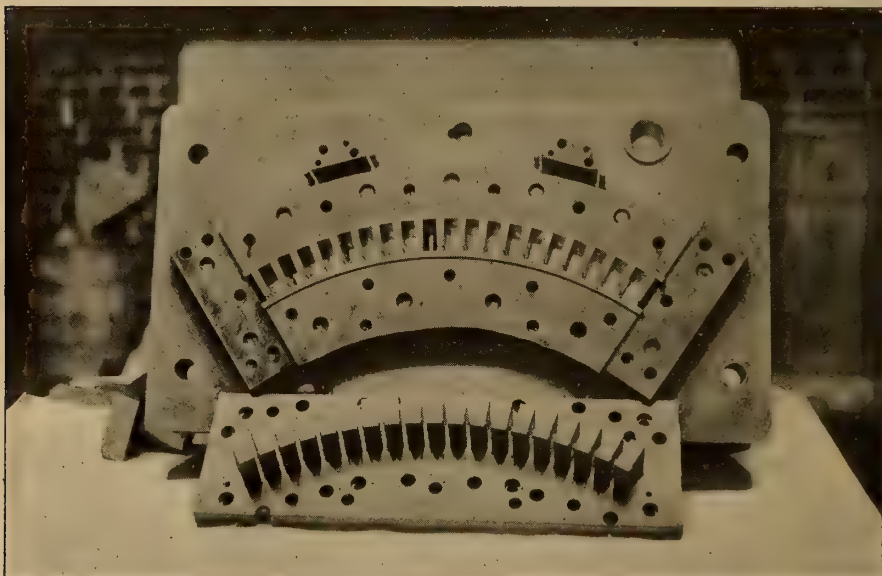
1. Valve with an adjustable stop or gauge on it.
2. Drum with petcock for draining off the water which appears when the air expands.
3. Safety pressure valve set for about 1½ pounds to the square inch.
4. Valve for regulating the supply of air to the furnace.
5. Fitting to prevent possibiility of high-pressure air backing up into gas supply pipe.

parts of the surface to which no lead adheres. Efforts to prevent this trouble only seem to aggravate it or to develop new ones equally objectionable or worse. Likewise, impurities in the lead not infrequently damage the surface of the tool with which it comes into contact, especially at the white heat to which it is subjected in hardening high-speed steel. Holes and interstices sometimes remain filled with lead when the tool is withdrawn for cooling, and the result is worse, even, than when flakes

of lead should adhere to the surface.

All these and other difficulties are overcome by the barium bath process. The chloride does indeed give off fumes unless precautions are taken to prevent; and a thin coating of it adheres to the tool when it is withdrawn from the bath. This, however, is just what is required in order to prevent oxidation while the tool is exposed to the air; and since the film is evenly distributed, there is no uneven hardening. It is possible also to maintain a more uniform temperature, since the melted barium chloride circulates freely, much more so than the heavier lead, so that the temperature throughout the bath does not vary sufficiently to be taken into account.

Heating in a fluid is no quicker than in an open fire or on a good furnace. Evidently, however, if the bath itself is uniformly hot throughout, the heating of the tool must be absolutely even. Projections cannot be melted down nor burnt before the interior has had time to reach the same heat as the outside, since it cannot get hotter than the bath, and that is kept uniform at the temperature required for the kind of tools in hand. The danger of blistering the surfaces or melting down the corners of a tool put into a white hot furnace without sufficient pre-heating is entirely obviated. Even if the bath should for any reason be at a temperature high enough to damage a delicate tool thus suddenly subjected to an intense heat, the barium cloride has a melting temperature so high that a relatively cool object plunged into it immediately causes a coating of it to solidify around the article. The coating of solid barium chloride then protects the enveloped article until its temperature rises sufficiently to melt it off.



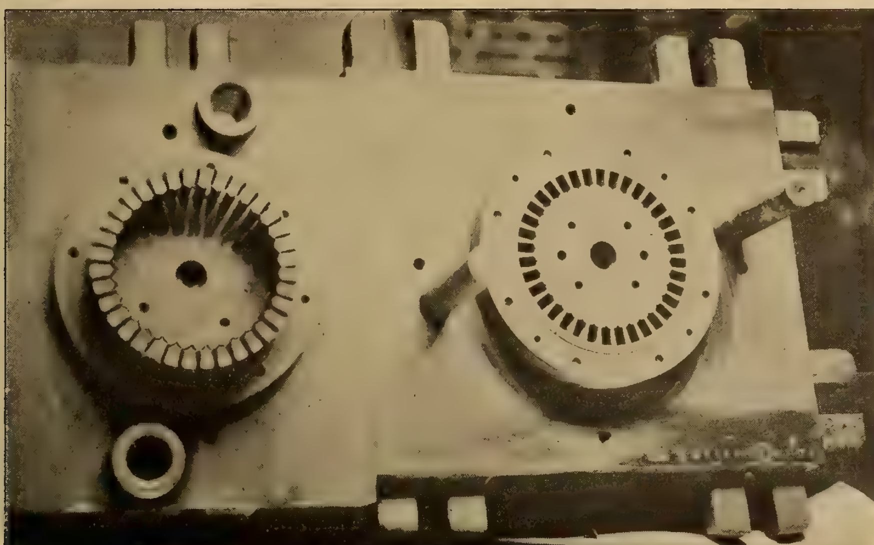
DIFFICULT EXAMPLE OF HARDENING BY THE BARIUM CHLORIDE PROCESS. BLUE CHIP STEEL

The furnace used for hardening by the barium chloride process may be of any form which will admit of a crucible of suitable size being properly supported and adequately and uniformly heated. A vertical gas furnace is preferred, one so designed that the nozzles direct the flames not directly at (in which case holes might be melted into it before the contents became sufficiently fluid

to absorb the heat rapidly), but past the crucible so as to envelop it in a whirl of heat which is absorbed uniformly over its surface. The crucible sits upon pieces of fire brick (to prevent the bottom falling out, as well as to support its weight) disposed at the bottom of the fire chamber in such a way as to allow the flames to circulate below, as well as around its sides. The supply of air and gas and the pressure would be the same as for any furnace of similar type, but used without the crucible and its contained barium bath.

The furnace should, by all means, be equipped with a good pyrometer for the accurate determination of the thermal condition of the bath at frequent intervals. The crucible itself should be of graphite, and so adjusted as to height that the top rises up into and fits rather snugly against the inner walls of the circular opening in the top plate of the furnace. The crevice is then luted up with fire clay to prevent gas or flame emerging and possibly discoloring tools or interfering with the action of the bath. It is well also to have a swinging cover, which can be quickly and easily placed over the top when desired. It is sometimes convenient to have a small opening through this cover. Of course the fire chamber should be vented, preferably into a stack.

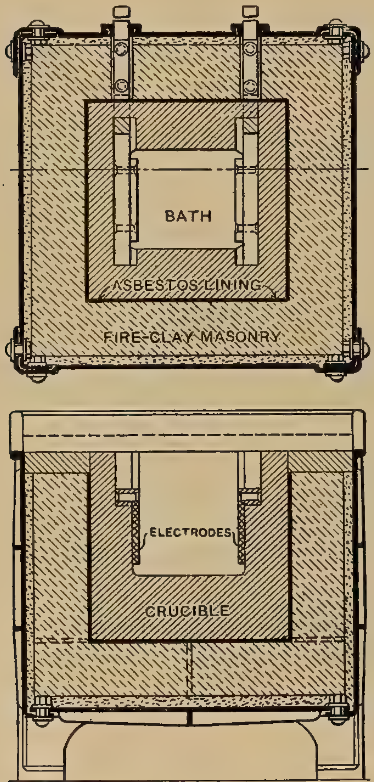
In practice the crucible is filled with commercial barium chloride* mixed with a small proportion, say about 2 per cent. of sodium carbonate, commonly called soda ash. The two substances must be melted together, else explosions are liable to occur sufficient in force to be serious. The soda ash, after the contents of the crucible have been melted down, floats upon the surface of the barium chloride and prevents the rising of chloride fumes. These are offensive and very irritating when breathed, and also discolor the surfaces of tools with which they come



ANOTHER EXAMPLE OF DIES (BLUE CHIP STEEL) HARDENED BY THE BARIUM PROCESS

* Barium is one of the small group of alkaline earth metals which includes also calcium (lime) and strontium. Magnesium is sometimes included in the group also. Barium never occurs free, in nature, its most common natural compounds being heavy spar and witherite. The metal itself has no present use in the arts, though it is intrinsically very interesting. It is moderately hard, yellowish, fusible at about 240 degrees C., and burns in the air with great brilliancy. Commercial chloride of barium now sells in quantity at about three cents per pound.

into contact. The soda ash also appears to have some additional effects, as yet not well understood. It gradually becomes exhausted and requires renewal from time to time. Care must be taken always that the proportion does not exceed approximately that already indicated. If it does, the temperature of the bath is not so easily regulated. The boiling



ELECTRICALLY-HEATED BARIUM CHLORIDE FURNACE AS USED BY LUDWIG LOEWE & CO., BERLIN, FOR USE WITH THE BARIUM PROCESS FOR HARDENING HIGH-SPEED TOOLS

point of the bath is raised and the temperature cannot be brought high enough to give the proper hardening heat.

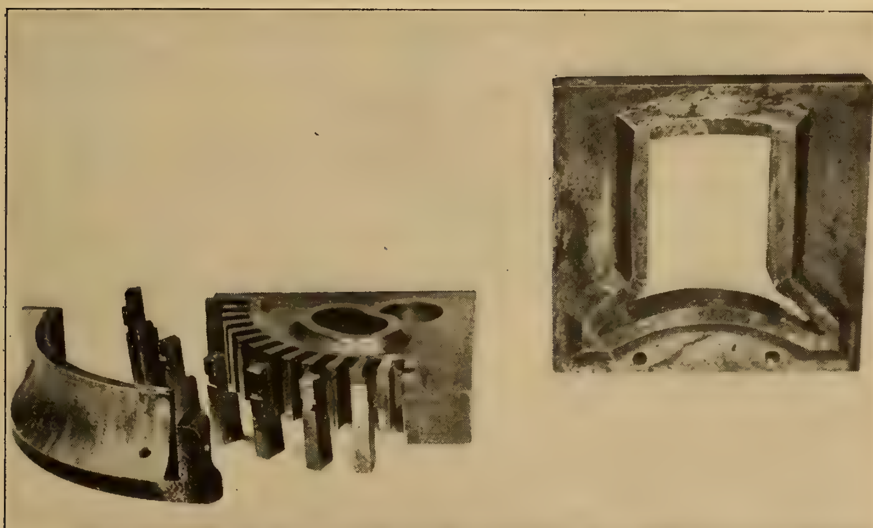
The bath is rapidly brought to the required temperature, which will vary somewhat according to the class of tools to be hardened, as shown in the preceding chapter. In general the temperature will be somewhere near, and usually somewhat below, 1,200 degrees C., being raised above that point or lowered beyond it as may be required. The exceedingly high temperatures to which roughing tools are raised (1,300 to 1,500 degrees C.) are unnecessary for the kind of tools to which the barium process is best adapted. Those high temperatures are sufficient to melt down cutting edges and affect the surface finish of tools, and one of the reasons for using this process is to avoid precisely this thing, or the possibility of it.

The bath being at the proper temperature, small tools may be immersed and left until they have attained throughout, the same temperature as the bath. The time required will necessarily vary according to the size and form of the tools, but in the case of small and regularly shaped tools it will range from a few seconds to a minute, or possibly two minutes. Larger tools, of course, require a longer time to become heated through, while those of a half-inch section, or smaller, should be ready in less than a minute. The operator must learn to gauge the time by actual experience. This is comparatively easy with the barium process, for, since the temperature of the bath is no higher than that to which the tool is to be raised, the latter is not damaged by remaining in the bath for some time longer than would be necessary merely to heat it through uniformly. It is well, nevertheless, not to leave tools in the bath for any considerable time longer than actually necessary.

When withdrawn from the melted barium chloride, the tool is seen to be covered by a thin film, which serves to prevent the surface coming into contact with the air. It is this feature, perhaps, more than any other one, that gives to the barium chloride process its distinctive value. The tool can be quenched in oil without having at any time from the moment the heating began, been ex-

posed to oxidation. The coating of barium chloride protects the tool to a considerable extent, also when the cooling takes place in an air blast, though it flakes off more or less and leaves spots exposed to the action of the air. The better way is to quench in oil.

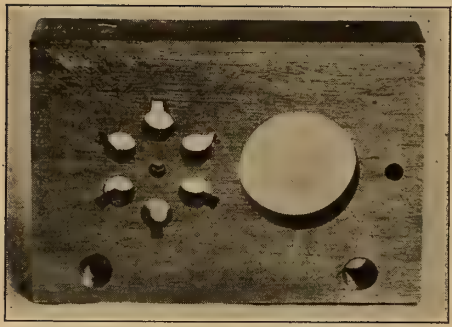
All tools of any size, say above ⅜ inch in section, should be pre-heated before being placed in the barium bath, and in certain cases it is desirable that small ones also receive this treatment. If a large unwarmed tool be suddenly plunged into the bath it chills the melted barium chloride so that it is then necessary to bring this again to the required point. This happens also to a much less extent when a tool which has been pre-heated is plunged into the bath, since the temperature of the tool is necessarily considerably below that of the bath. Evidently, then, it is desirable that the bath be ample enough to minimize fluctuations due to this cause. Small tools, of course, do not have any important influence in changing the temperature of the bath, and so far as this point is concerned may be put into it without pre-heating. It is very important that the temperature of the bath be carefully watched and regulated as may be necessary. The experienced operator, of course, learns to judge very closely by its appearance and behaviour whether or not all is right, but even he needs to check up his judgment against a reliable pyrometer from time to time, the influence of a passing shower, even, changing the brightness of daylight as it does, is sufficient to make error easily possible in judging the temperature by the eye. The operator with limited experience must, of course, be very largely guided by the indicator or record, as the case may be.



DIES AND FORMING TOOLS HARDENED BY THE BARIUM PROCESS

Heating tools in this way, preparatory to their being placed in the barium bath, effects a considerable saving in time when many are to be treated. Several are kept in the pre-heating furnace or bath, and are given the higher heat treatment in turn.

For pre-heating, any convenient furnace can be used, though the reliability and convenience of the gas-oven furnace especially recommends



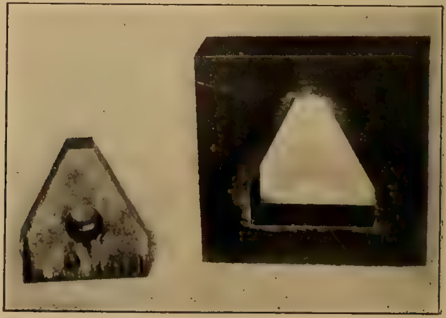
BLUE-CHIP STEEL DIE HARDENED BY BARIUM CHLORIDE PROCESS

it for this purpose. The lead bath also is very convenient. The heat is carried up to a low red, not above 600 degrees C., and preferably somewhat below this point. At this temperature no oxidation occurs, and it is perfectly safe to raise tools to this point in the gas furnace and then carry them through the air to the barium bath. Obviously the temperature of the furnace or bath must be maintained uniformly at the point mentioned, else some of the tools will get hot enough to scale more or less. Of course where the barium process is used in hardening tools when this is of no consequence, the temperature in the pre-heating furnace can be as high as desired.

It has been mentioned already that the air blast disintegrates the film of barium chloride which adheres to the tool when withdrawn from the bath, and that it is on that account better to quench in oil. For this purpose no special appliances are necessary; the oil bath already described in connection with ordinary hardening methods serves excellently. The net basket, into which small tools can be thrown without further attention until they are removed, makes this tank particularly convenient for use with the barium process.

The oil, like the air blast, disintegrates the coating of barium chloride investing a tool when taken from the heating bath. When the scales are brushed away and the oil wiped off, the surface is seen to be as

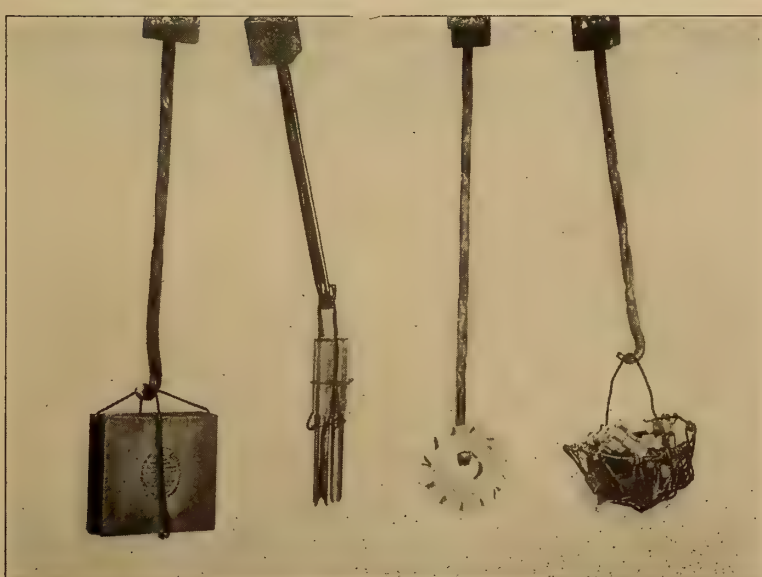
BLUE-CHIP BACK KNIFE FOR WOODWORK. BACK MADE OF SOFT STEEL. BLUE-CHIP BLADE RIVETED ON. FIRTH-STERLING CO., PITTSBURG, PA.



DIES HARDENED BY BARIUM CHLORIDE PROCESS. BLUE-CHIP STEEL

BLUE-CHIP HOLLOW MILLS HARDENED BY THE BARIUM CHLORIDE PROCESS

smooth, and every cutting edge as keen and perfect, as it was before treatment. Not only is the finish unimpaired, but even the color is almost exactly as bright and fresh as when the tool was first machined or ground. Even an expert could not tell, merely by looking at it, whether a tool had or had not been hardened, unless, perhaps, by comparing it with one known to have been or not to have been treated. It has happened a good many times that purchasers have returned tools treated by this



METHOD OF SUSPENDING TOOLS IN BARIUM CHLORIDE BATH

process, before trying them, thinking from their appearance that they had not been hardened.

A number of things are possible* with the barium process which were only dreamed of before its development. High-speed steel taps and threading dies, and tools used for similar purposes, have, until recently, left much to be desired. Almost invariably, when hardened by the customary methods, they lose size slightly or have a roughened surface, which interferes with their perfect working. Furthermore, the shrinkage is not at all uniform, in some instances varying several thousandths of an inch, even in tools of the same diameter, by reason of imperfectly regulated heating conditions and the inherent imperfections of the usual methods when dealing with this particular class of high-speed tools.

The barium process entirely overcomes this difficulty. And not only can the size be maintained with almost absolute uniformity, but the tools can be hardened in such a way that they combine the greatest possible cutting powers combined with a superior toughness of supporting stock, to prevent breakage under the high stresses to which they are thus subjected. This, taken together with the circumstance that the size is not altered, the finish is left perfect, and the keenness of the cutting edges is unimpaired, especially adapts it to the hardening of many tools (like those already mentioned, as well as many other kinds) to the making of which high-speed steel has not heretofore seemed well adapted. Taps, threading dies, and other tools with overhanging teeth or cutting edges, which, when properly hardened, were likely to break off or crumble, or when let down sufficiently to overcome this difficulty are too soft to last long, can have these teeth or

A DAY'S WORK. HARDENING BY THE BARIUM PROCESS. DIES OF BLUE-CHIP STEEL

* It may be of interest to mention in this connection that the barium bath is also excellent for hardening carbon steel tools. hen so used potassium chloride may be mixed with the barium chloride to form the bath, in the proportion of about two to three.

cutters hardened to any desired extent, while the body of the tool remains in the annealed condition.

The modus operandi is exceedingly simple. All that is necessary is to plunge that part of a tool which is to be hardened into the bath, preferably after the customary pre-heating, just long enough for the teeth or cutting edges to become thoroughly heated through to the required temperature, and then withdrawing it before the stock or body has had time to become heated enough to harden when cooled. The tool is then quenched in the usual manner.

It is to be remembered that heating the exterior of a tool only, and then suddenly cooling it, as is required by this method, often sets up strains and causes flaws, because the outside and inside portions have not, in cooling, had time to adjust themselves properly. A little care on this point will minimize the difficulty; and the subsequent "tempering" to which most tools of these classes are subjected, can be made to relieve any strains which may have been set up in the hardening.

Dies and other tools subjected to repeated blows or heavy pressures can be hardened in a somewhat similar way, thus avoiding a trouble which it was not possible, before the development of the barium process, to circumvent—that of dies made of high-speed steel breaking or splitting open. A die may have its face hardened, as the cutters described above have their teeth hardened, by this part alone being placed in the bath, leaving about half of the body not brought to the high heat. This method is, of course, especially useful in the case of dies with relatively heavy bodies. Care must be taken, in this case, to move the die more or less according to size, in such a way as to avoid a distinct line of demarkation between the hardened and the unhardened portions.

THE 100-HORSE POWER GAS ENGINE

CURRENT BRITISH PRACTICE

By T. W. Burt

IT is not the writer's intention to discuss the merits of, or the advantages accruing from, the use of suction gas engines and producers, as this has already been done by numerous writers on the subject. That the suction plant has established itself as a recognized source of power is undoubted; this is indicated both by the large volume of orders makers have on hand and by the number of new makers entering the field.

The strongest advocate of suction gas cannot but admit that lately, particularly with sizes over 100 horsepower, much trouble has been experienced, which will undoubtedly tend to delay progress temporarily, on account of the unwillingness of power users to decide on an installation of suction gas when the risks of unforeseen stoppage have to be taken into account.

On analysing this trouble one finds it usually due to one of two causes, viz.: either the plant is too small for the work required of it, or there is a want of proper attention on the part of those in charge. Some purchasers do not allow a sufficient margin of power when installing a new engine; probably on account of their experience of the steam engine's overload capacity they assume that the gas engine has a similar reserve.

When a gas engine, like any other machine, is working up to its maximum output, everything must be maintained in the best possible condition, otherwise troubles arise.

It should be a recognized rule that a margin of from 15 to 25 per cent. be allowed between the maximum power of the engine and the constant working load required of it, depending on the nature of the work.

Certain makes of suction gas installations display a tendency on the part of the engine to slow down and sometimes stop altogether a few minutes after starting up.

The study of a number of such cases points to the conclusion that this is often due to the attendant neglecting to carry out the maker's instructions. Still it must be admitted that, in some cases, the trouble is due to faulty design, for there are certain types of producer which never give this trouble. One particular instance is known to the writer of a 100 brake horse-power installation which starts without any preliminary blowing up of the producer at all. The engine is arranged to start with compressed air, and after raking out the fire the attendant sets the engine in motion and puts it on to its load at once. This most desirable condition of affairs is due to the following amongst other causes: The ample size of the scrubber, pipes and expansion box, which latter is placed close to the engine, the arrangement of the water seal whereby the scrubber, pipes and expansion box always remain full of gas; the arrangement of the waste pipe and the ample size of the generator, which allow the fire to maintain a good temperature while the engine is not working, and the extra air inlet on the generator, whereby less steam is drawn into the generator at first, allowing it to get hot more quickly. The generator is situated about 30 feet from the engine and the gas contained in the scrubber, pipes, etc., keeps the engine working until the fire is drawn up to

the necessary working temperature.

Difficulty is experienced in getting suitable attendants, for whilst the general principles of the suction gas plants are becoming more widely known each year, yet the class of men suitable for this work have little or no opportunities of acquiring the necessary knowledge. Naturally the best class of man is one who has had experience with city gas engines, and almost invariably when suction gas replaces illuminating gas there is very little trouble. The failure of the majority of men is that they will not follow accurately the instructions given by the makers, and again, a class of men is met with who seem to know more than the makers themselves and can effect improvements and make alterations, with the result that troubles soon begin to appear. On the other hand much ingenuity is often displayed by the man in charge and many little improvements, applicable to the special circumstances of the work, result from his interest in his duties.

A good suction plant requires very little attention, and if the maker's instructions are complied with and the installation is, as far as possible, kept in the same condition as when taken over from them, then there is no doubt of success. It is good policy rather to clean a valve or sparking plug oftener than is absolutely necessary than to wait until the working of the engine shows it is required, either by unsatisfactory running or the stoppage of the whole installation. In all instances the key word is cleanliness, and purchasers should personally see that attendants bear this in mind, for from the want of a little attention inconvenient stoppages with their attendant expenses, sooner or later occur.

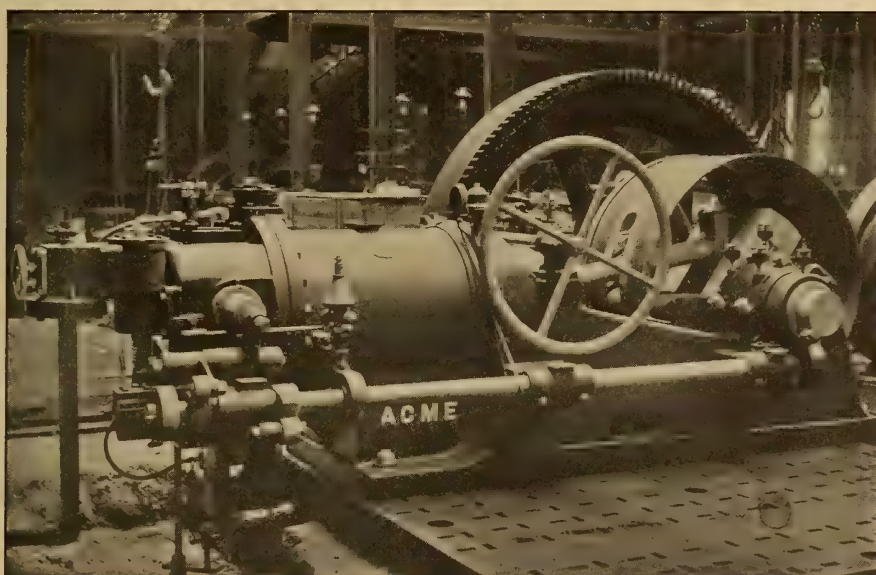


FIG. 1.—THE ACME GAS ENGINE, BUILT BY THE ACME ENGINE COMPANY, GLASGOW

It is now proposed to deal with the general design of the different makes of engines, to compare in detail the various fittings, etc., and as far as possible to anticipate future developments. For this purpose several of the best-known makes will be treated, and as the 100 brake-horsepower engine is now being installed in ever-increasing numbers, it is proposed to confine our consideration to this size.

For a number of years great differences of opinion have existed with regard to the arrangement of the cylinder and combustion chamber, or cylinder end, and the majority of makers adopted casting these in one and bolting the whole to the bed casting. The popularity of this construction was due principally to the lead given by Messrs. Crossley Brothers, which other makers in some way desired to follow. On the other hand, some makers preferred to cast the cylinder and the cylinder end separately, amongst whom were the Stockport and Acme companies, on both of whose engines the cylinder jacket is cast solid with the bed. From experience of both methods we cannot understand the popularity of the former, and the wisdom of the Acme and Stockport companies in adhering to their own design is now evident, for in addition the Campbell, Kynoch, Ruston, Crossley, Paxman and National engines are all made in this manner on this size of engine, except that the three latter firms still cast the cylinder jacket separate from the bed and bolt it thereto with studs equally divided round the flange, but Messrs. Tangye still adhere to the old system, the cylinder in this case being fixed to the bed by seven 2-inch studs.

Messrs. Crossley adopt the girder type of bed as shown in Fig. 2, but this type does not appear to be gaining in favour.

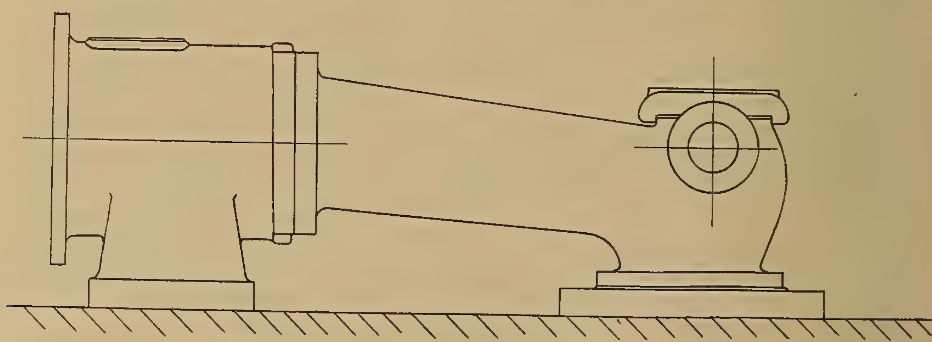


FIG. 2.—CROSSLEY GAS ENGINE BED

The cylinders are usually made 19½-inch or 20-inch diameter, and on those engines having the cylinder jacket and bed cast in one, the prevailing custom is to carry the latter back under the cylinder, almost up to the back flange of the cylinder; this makes a very rigid engine.

Trouble used to be experienced in old designs with the water which passed through the joint between the cylinder and the cylinder end leaking into the combustion chamber, but some years ago the method was introduced of a separate circulation for each of these parts, which proved very successful and is now more or less generally adopted.

With this arrangement of water circulation the liner is drawn in from the back and held in position by the cylinder end, the front bearing on the liner being fitted with a rubber ring, and this allows of it getting free scope to expand and contract without setting up any strain. The liner is usually shrunk into position, but on the National engine it is put in with the front bearing quite easy and with a certain amount of play. The joint between the back end and the cylinder face should be jointed up, metal to metal, with the former bearing on the liner end. Fig. 3 shows the method adopted with the Acme engine in this respect.

The construction of the front part of the bed is undergoing some changes, and the tendency is very

marked to follow the German practice and make the main bearings horizontal instead of angled, as heretofore. For cheapness and ease of adjustment and erection the horizontal has advantages over the angled bearing, while in actual working results there is probably not much to choose between them. Messrs. Crossley, Kynoch and Campbell adopt the horizontal bearing, but all the other well-known makers still adhere to the angled type. On the Tangye engine each journal bearing cap is held in position by two 2-inch studs, while on most of the other makes four 1¼-inch or 1½-inch studs are employed, which latter is probably the better construction, considering that the bearing is at least 16 inches long.

The practice introduced some years ago on the Acme engine of casting an oil gutter round the bottom of the bed is now being followed in the Campbell, Kynoch and Ruston engines.

Being the most vital part of the engine subjected to the wear and tear, and working as it does under very severe conditions, the piston has received special consideration. Some makers, such as Kynoch, Ruston and Tangye, consider that for satisfactory service it should be water-cooled, but others, such as National, Hornsby, Crossley and Acme, do not consider this extra complication necessary, and there are numerous engines of these latter makes working successfully, even up to 24-inch cylinders. By water-cooling is meant that the back end of the piston is made with a double wall, and the chamber so formed is kept full of water, the hot water leaving at one side and the cold water entering by the other. These passages are connected with tubes bolted to the bed, which slide in stuffing boxes in the piston. These stuffing boxes are often a source of trouble and require constant attention. It is an undoubted fact that much skill and experience are required properly to design and fit a piston of this size, but when this has been acquired, the necessity for water-cooling, with its additional expense and complications, vanishes. As the piston in an engine of this type has to perform the duties of a cross head guide as well, the prevailing custom is to make the length of

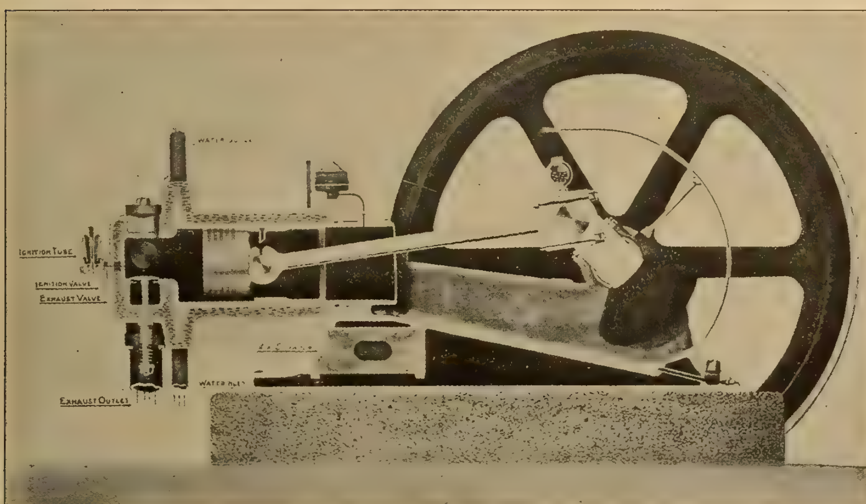


FIG. 3.—LONGITUDINAL SECTION OF ACME GAS ENGINE

the piston about twice the diameter.

Crankshafts have in the past been a source of serious disappointment, trouble and expense, and as the sizes cannot with any degree of certainty be calculated, it is only by trial and error that a guide to the proper dimensions can be obtained. In former years cranks were made much too light, but slowly and surely makers are increasing their sizes to meet the indeterminate stresses and strains, as well as to give much larger bearing surfaces. In addition to this the practice of fitting two flywheels is gradually being abandoned in favour of the single flywheel and outer bearing, and this also makes for increased strength, for the insurance reports show that a greater percentage of the former type of crank than of the latter.

The revolving weights were usually balanced by casting pieces on to the flywheel rim except on electric-light engines requiring very accurate balancing, in which case weights were fixed to the crank webs. As this method is an improvement on the former, the Acme Engine Company fitted these balance weights to all types and sizes of engines made by them, and so this is now a general practice, excepting notably on the Crossley and Tangye engines. These weights are of cast iron and carefully fitted to the crank webs and each held in position by a 2¾-inch bolt and in some cases by two 2-inch bolts. We give in Figs. 5 and 6 drawings of Tangye and National crankshafts, from which it will be observed that the main bearings are 8 inches diameter by 16 inches long, except on the Tangye, which are 15 inches long. Although on those two engines the crankshaft is carried along the same diameter to the outer bearing, it is better practice to swell it a little, so as to counterbalance the weakening, due to the key beds, which are usually 2¼ inches wide and sink ½ inch deep into the shaft. The outer bearing is generally made 6 inches diameter and 12 inches long.

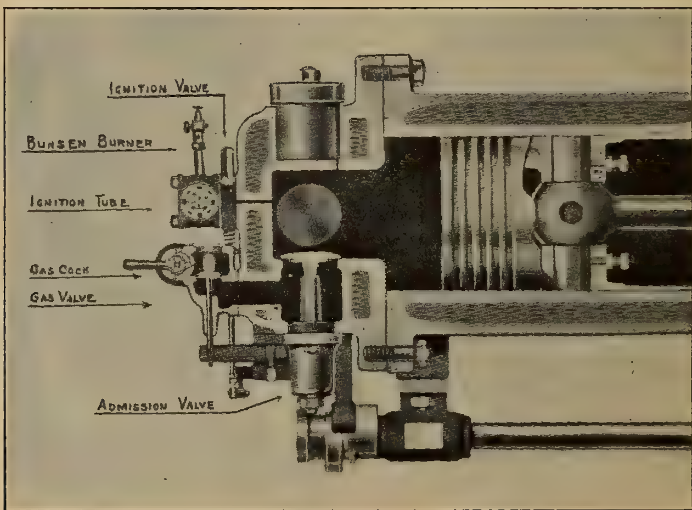


FIG. 4.—DETAILS OF CYLINDER-HEAD CONSTRUCTION OF ACME GAS ENGINE

It is now the general custom to fit a crank eyelash guard, completely encircling the revolving parts, but Messrs. Tangye, except on their electric lighting engines, do not fit a guard of any description. The style of guard varies considerably, Messrs. Crossley and National fitting a plain painted sheet-iron one, whereas that

on the Hornsby, Kynoch and Acme engines is of planished steel, with a polished beading or band along the edge.

In the arrangement of the connecting rod small end practice varies, as some makers, such as Messrs. Tangye, make it a solid ball, whilst others, such as Acme, National, etc., make it similar to the big end. With a large cylinder, when everything can be made of ample strength and accessibility, the latter method is probably the better. In that case the bolts are generally made about 1½ inches diameter, but those on the big end vary greatly, from 1⅝ inches on the National engine to 1⅞ inches on the Kynoch and 2 inches on the Tangye. Great care is necessary in fitting these latter bolts, and in addition a projection should be turned on the end of the connection rod to fit into a check on the brasses. This is not fitted on some engines, such as the Tangye, but as the crank-pin bolts are subjected to bending as well as tensile stresses, due to the motion of the revolving parts, this projection helps to relieve the bolts. It should be made of ample size and accurately fitted. The connection rod itself should be about 4¼ inches in diameter at the crank-pin end and 3¾ inches at the other end.

Now that the shafts are being made more in proportion to the duties they are called upon to perform, white metal-lined bearings are no longer necessary or advisable, and those made of the harder alloys give better results. An oil of suitable body must, of course, be used to get the best results, and the waste oil from the engine should not be used unless after filtration. For bearings tending to heat we find a good oil consists of a mixture of steam cylinder oil and machinery oil kept as thick as will feed through the lubricators, and a case occurs to us whereby the only oil capable of running certain bearings cool was the waste from the cylinder.

The piston-pin bearing has to stand very severe usage, often working

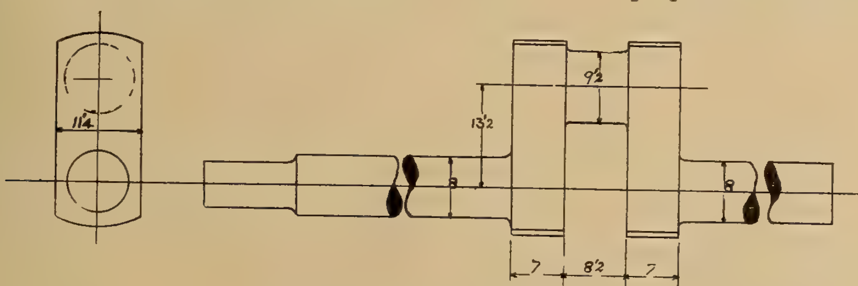


FIG. 5.—TANGYE CRANKSHAFT

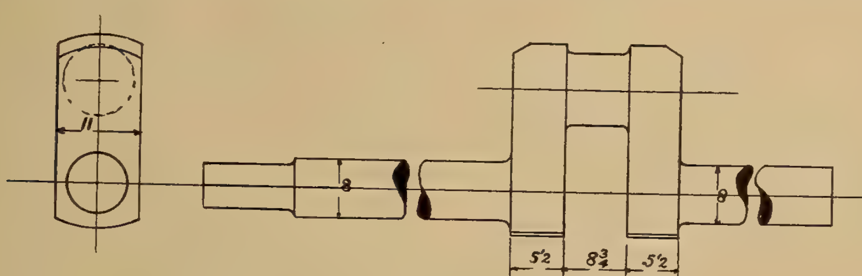


FIG. 6.—NATIONAL CRANKSHAFT

under average conditions as regards heat and lubrication, and for this reason it is made about 7 inches diameter and preferably of phosphor bronze. If the pin itself is made hollow there is not the same tendency for it to distort the piston when heated, and so better working results are obtained.

The flywheel is generally, for ordinary work, about 8 feet diameter by 15 inches wide, weighs about 4 tons and in some cases is split so as to give a greater grip on the shaft. The Crossley engine, it should be noted, has two light flywheels, each 7 feet 6 inches diameter. This latter firm appears to be the only one now fitting two flywheels on this size of engine.

The cams are generally made of cast iron, and much attention has been devoted to finding the correct shape, combining quietness with efficiency. Probably the best shape for these conditions is that adopted on the Acme and National engines, although the latter firm appear to make the cam the reverse way to get the best results. Greater attention is being paid to silencing the valve gearing and less clearance is given between the valve ends and operating lever, although care must be taken not to adjust the exhaust-valve lever too closely, else when the heated valve expands it cannot sit down properly on its seat.

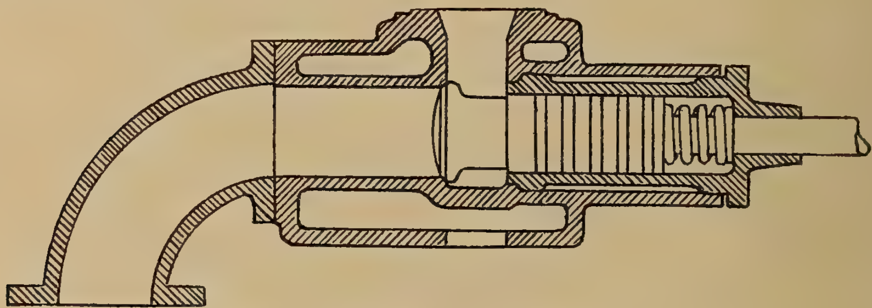


FIG. 7.—CROSSLEY BALANCED EXHAUST VALVE

As the gas engine increases in size, the strain imposed on the valve mechanism assumes increased proportions, and for this reason it is necessary that the driving gear be of ample strength and rigidity. When it is considered that the force necessary to raise the exhaust valve exceeds 30 cwts., and is exerted from 60 to 80 times per minute, one can understand the need for making the cam shaft and bearings a good, strong job, so as to ensure quietness and long life. A common size for the shaft is 3¼ inches diameter supported by three bearings, except on the National and Crossley engines, where only two are fitted. The skew gears are completely enclosed now in an oil bath and are adjustable.

Little novelty is displayed in connection with the valve arrangement, and the majority of makers follow the German practice of putting the admission valve vertical, immediately above the exhaust valve. Why this arrangement is so popular is hard to tell, for it seems to possess no advantages in construction or operation over the horizontal valve. True, horizontal valves are said to wear quicker than vertical ones, but this has not been found to be the case in practice. With some makes of engines a rearrangement of the valves was necessary for suction gas in order to increase the compression, and putting the admission valve on the top certainly enables a very high compression to be attained, although with a horizontal valve from 140 to 150 pounds per square inch can be

reached, which is quite high enough for present requirements.

With a variable quantity governor, such as is used on German engines, a high compression is necessary (about 180 to 200 pounds per square inch), so that it will not be too low at light loads when the mixture is throttled down, and this, together with mechanical reasons to suit the type of governor employed, is why this arrangement is adopted abroad. However, this type of gear is rapidly gaining favour, although Messrs. Crossley and Acme still adhere to the horizontal valve, and indications point to its ultimate adoption even on smaller engines. With the better design of the combustion chamber, whereby the cooling water is brought right up to and surrounds the valve seats, these now require much less grinding than formerly, and when the exhaust valve is water-cooled internally it will run for many months without attention. Generally all engines of this size have the internally water-cooled exhaust valve, which is generally made entirely of cast iron. It should be noted that a balanced valve is fitted on the Crossley and Campbell engines, which reduces the force required to raise it from about 30 cwts. to about 4 cwts. This is operated on the Campbell engine by having a piston attached to the valve spindle and a connecting pipe led from the cylinder, which, when uncovered by the piston, allows the pressure to reach the balancing piston and thus relieve the stress on the valve, operating cam and lever, etc. On the Crossley engines, however, the valve is horizontal and contained in a separate block locked underneath the cylinder. Fig. 7 shows the arrangement, and it should be noted that the valve is pulled off its seat instead of being pushed, as is usually the case. The spindle, or properly the balanced piston of the valve, is fitted with a number of piston rings, has large bearing surfaces and is well arranged for ample lubrication. The cooling water enters through a rubber tube and cock at *A* and discharges at *B* into a filter connected by an inch box pipe to the waste. Ten gallons of water are used per hour, and it is recommended that the valve be ground into its seat once in three months.

The admission and gas valves are made with a cast-iron head screwed and riveted on to a steel spindle, and the heads are arranged for accommodating a tool for grinding purposes, but there should be no sharp edges or screw threads, which are likely to get red hot and cause premature ignition.

The combustion chamber should be made as simple as possible, and the explosions in the air pipe experienced with some engines are entirely due to the arrangement of the indicator and starting valve ports and pockets, which remain full of burning gases and ignite the incoming charge.

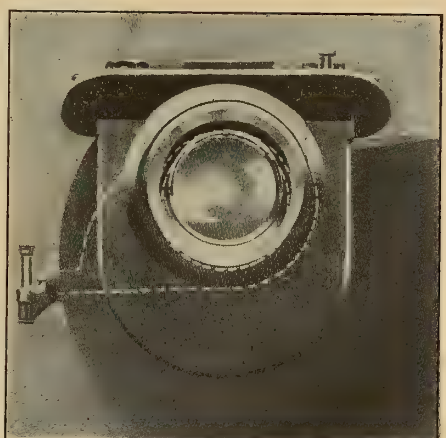


FIG. 8.—CROSSLEY MAIN BEARING

The exhaust valve spindles are now universally fitted with a sight feed lubricator and ample provision made for oiling the gas and admission valve spindles. The ends of the spindles should be screwed so that the thread takes up the thrust of the springs and these latter arranged so that they do not come in contact with the ingoing charge.

To simplify the cylinder and casting, the gas cock and valve box are made separate and bolted on, except on the National, Crossley and Hornsby engines, on which the valve box fits into the main casting. Taper key cocks are universally fitted for adjusting the gas supply; but these stick readily with the tar, and so more satisfaction is derived from a screw-down valve. In reality no minute adjustment of the valve is necessary with suction gas, as the best results are obtained by opening full the gas aperture and adjusting the mixture by means of the air throttle. This latter is generally a butterfly valve arranged with a handle and wing nut for locking in position; but on the National engines no handle is provided and a hexagonal nut is used for locking, which makes the use of a spanner necessary and is altogether very inconvenient.

The arrangement of the electric-ignition gear depends on whether the point of ignition is to be adjustable or not when the engine is running. To have this facility is a very questionable advantage, but still it is fitted on the Tangye, Kynoch, Ruston and Hornsby engines, and on account of this the gear is driven by an eccentric on the cam shaft. This arrangement is rather more expensive to construct and is more liable to wear than the simple fixed type, and from experience with both, we find the latter as fitted to the National, Crossley and Acme engines to fulfill all requirements. The average engineman is not capable of adjusting the ignition correctly and the fewer facilities he has of making wrong adjustments the better.

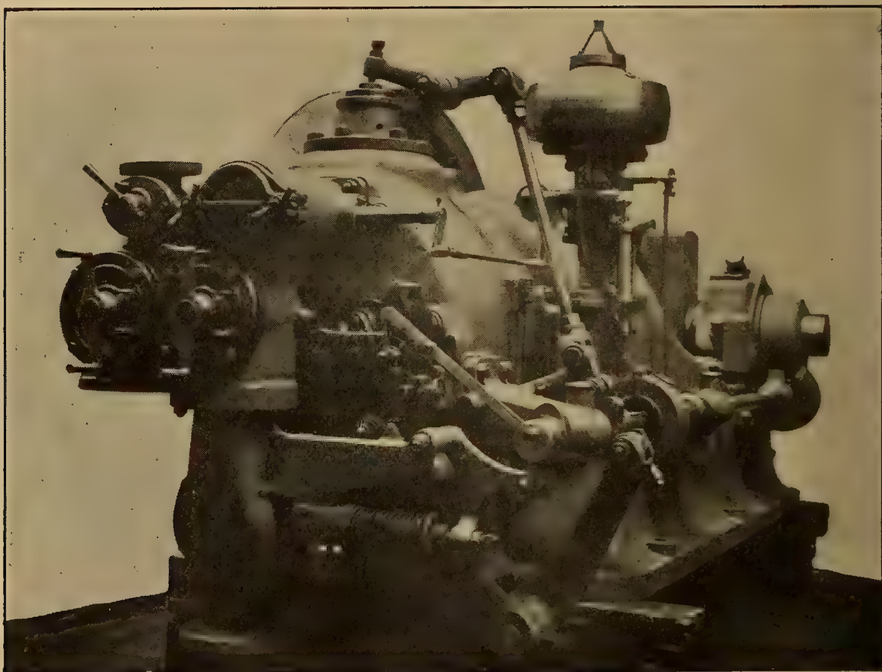


FIG. 9.—MAGNETO IGNITION GEAR ATTACHED TO GAS ENGINE. TANGYE, LTD., CORNWALL WORKS, BIRMINGHAM

We give illustrations of the gear as fitted to the Tangye and Hornsby engines as examples of the variable type. By altering the position of guide for the push rod used for tripping the magneto, this latter operation takes place earlier or later as

required to secure proper ignition. We also give a sketch of the simply fixed type, wherein the only adjustment available is in retarding the spark for starting. It is in arranging for this retard that many ingenious devices have been devised, and and as soon as the engine is started the finger is held against the stud *E*, and this latter revolves the pin *A*, and when they key *B* comes opposite the slot *C* the spring pushes it through and the engine is now on the early ignition.

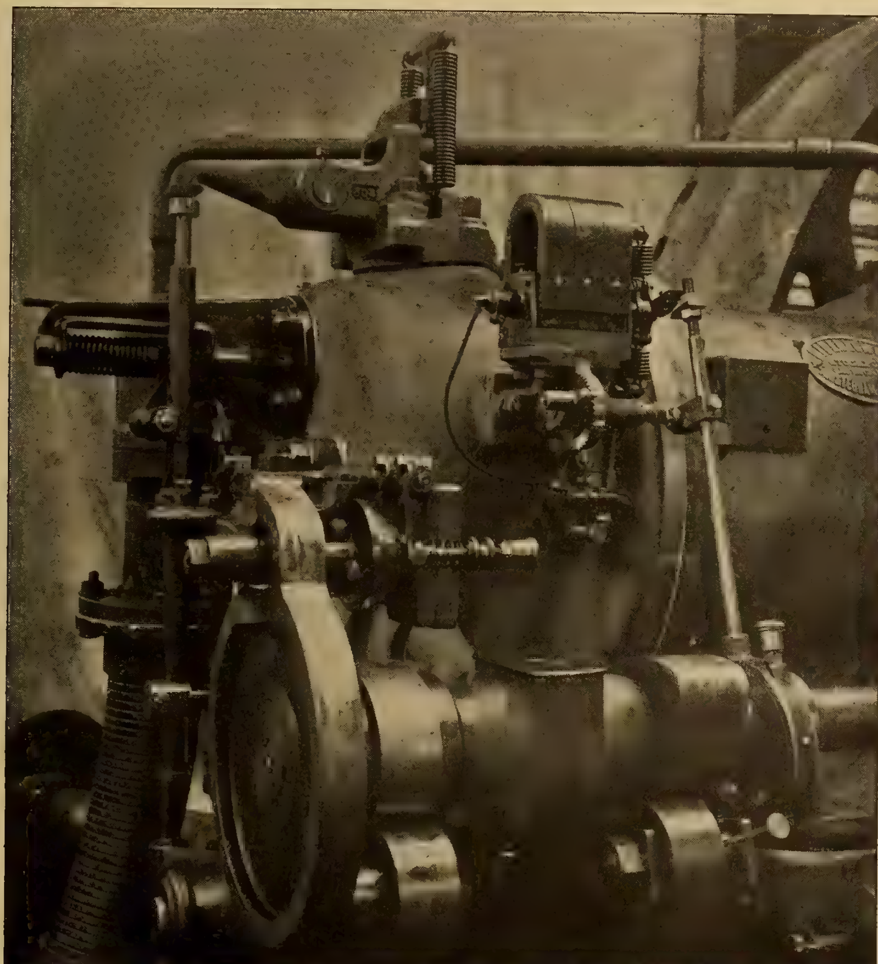


FIG. 10.—MAGNETIC ELECTRIC IGNITER ON HORNSBY-STOCKPORT GAS ENGINE

we illustrate that used on the National engines. The pin *A* is pushed forward and given a small rotary movement, whereby the small key *B*, which has passed through the slot *C* in the plate *D*, cannot get back again. This pin *A* keeps the magneto from tripping back till later in the stroke,

On the National, Kynoch, Hornsby, Ruston and Campbell engines, the ignition plug is fitted to the side of the cylinder, whilst it is fitted in the end in the Acme, Tangye and Crossley designs. Although it is claimed that the side position gives superior results, it is difficult to believe and

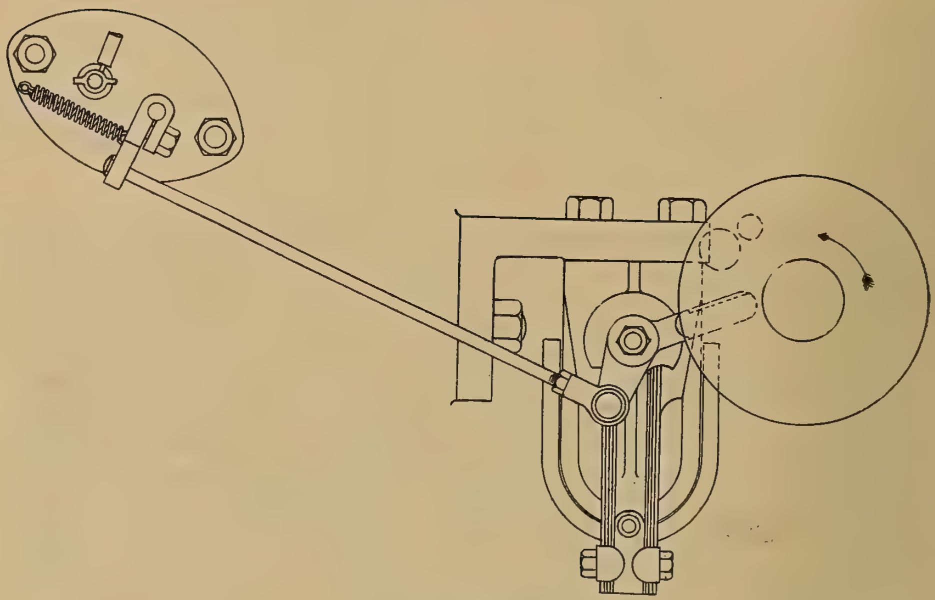


FIG. 11.—ACME MAGNETO GEAR

still more difficult to prove this, and each maker seems to fix the position to suit his particular design. In any case the plug should be kept as short as possible and the bevel-faced joint where it bears against the main casting should be as near the nose as possible, so as to shorten the surface liable to become coated with tar and moisture, which prevent the plug being easily removed. The National sparking plug is about 14 inches long, whereas those on most other engines are from 3 inches to 4 inches long.

The lever on the rocking hammer spindle is often fixed on to a taper, but a better way is to split the lever

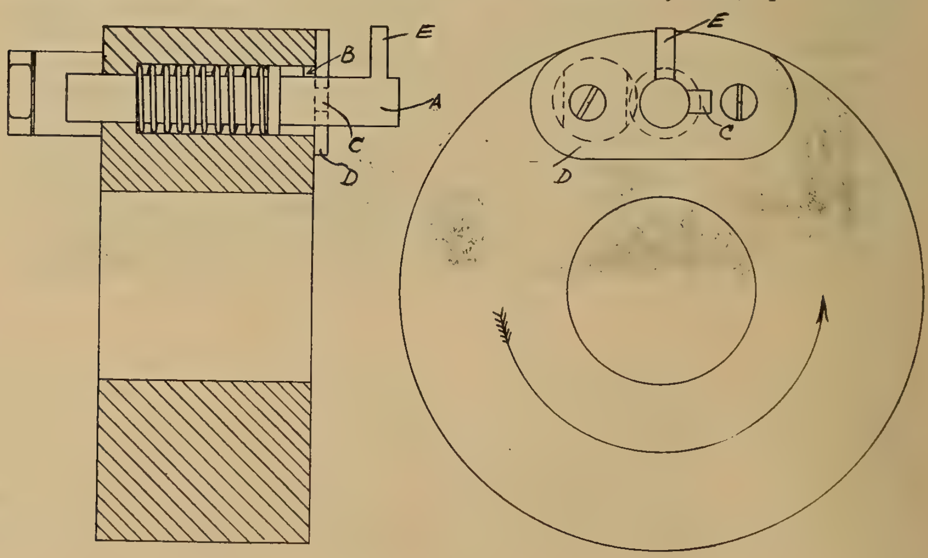


FIG. 12.—NATIONAL IGNITION CAM

through the boss and fix in position with a set screw, as is done on the Acme and Crossley engines and shown on the above sketch of the plug.

In order to reduce the cost of the hammer, lever, etc., malleable castings instead of forgings have been found to give good results and are cheaper to replace when worn. The springs for holding the sparking points together often fail on account of the continuous hammering to which they are subjected and, if made of piano wire, give more satisfaction.

Naturally in an engine of this size the question of starting is a serious one, and although the usual custom is to run the engine during the meal hours, as the extra fuel used is infinitesimal, thus making only one start per day necessary, still this start must be made with ease and assured success.

The hand pump type of starter is at present the most popular, such as on the National engine, using the suction gas and others, such as Tangye and Crossley using petrol. The pump piston is made about 4 inches diameter by 4½ inches stroke and, using petrol, about 20 strikes are sufficient for pumping in the explosive mixture, and about double that number with suction gas.

When a false start is made much turning of the engine is necessary to clean out the cylinder to enable a fresh start to be made, and as this type only gives one impulse, everything must be in good order and properly adjusted so that the engine may take up its sequence of explosives immediately. Messrs. Crossley, however, adopt a slightly different method, as will be seen from the following description of their starter.

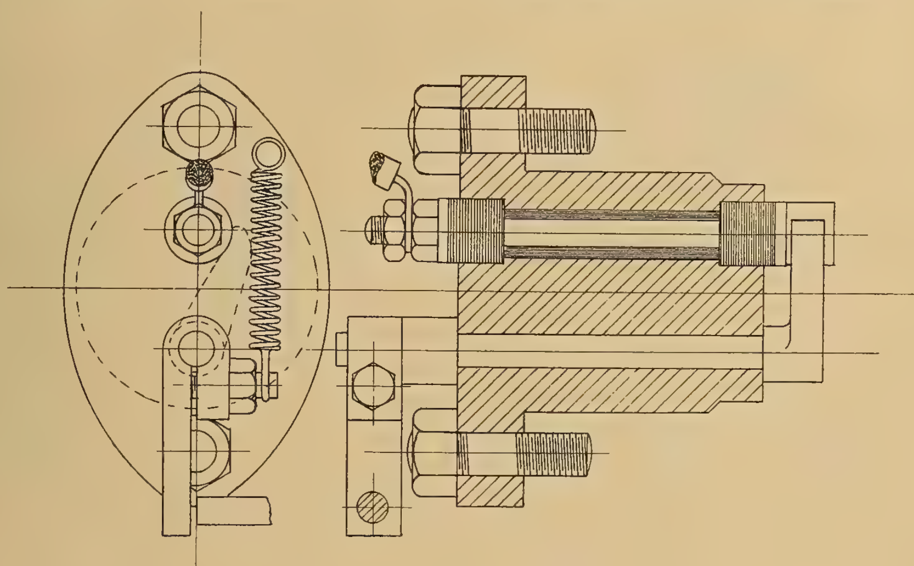


FIG. 13.—SPARKING PLUG

The hand pump is fixed to the floor and a tank 12 inches bore by 9 feet long is interposed between it and the engine. The crank is placed about 60 degrees above the in-center on the power stroke and the admission valve held open by a catch, while the charge of petrol vapour and air is pumped into the receiver and cylinder. The admission valve is now closed and the mixture ignited, at the end of the tank furthest from the engine, at atmospheric pressure. The expansion of the burning gases

causes the pressure to rise considerably, so that by the time the flame reaches the engine cylinder the pressure has risen sufficiently to give a good explosion. Immediately the engine moves off, the valve connecting the engine with the receiver is shut and, as part of the explosive mixture was forced into the air pipe through the open admission valve, this is drawn in for the second charge, after which the gas cock is opened for the subsequent charges.

mentum of the flywheel keeps it running long enough to replace the air lost from the receiver at the previous start, which is generally from 5 to 10 pounds per square inch. The arrangement of valve box for controlling the air, as fitted to the Acme engines, is shown on Fig. 14, and thus will readily explain the method of working. A cock is necessary on the air tank, preferably of the screw-down type, as taper-key cocks are not very reliable, and also between the

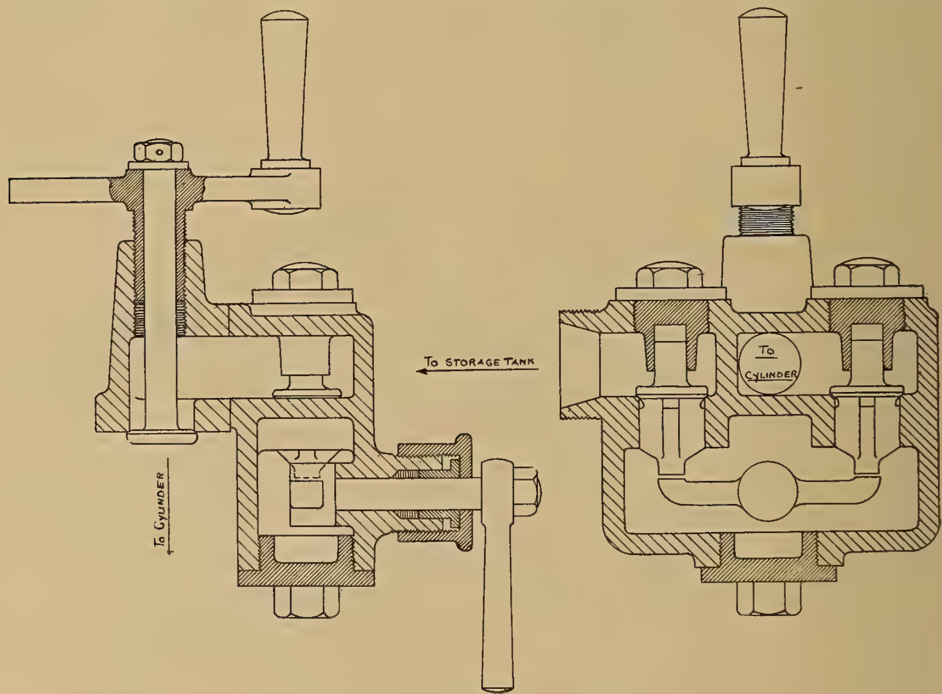


FIG. 14.—ACME COMPRESSED-AIR STARTER

When a supply of compressed air at not less than 80 pounds per square inch is available, then the best method is to employ this for starting, but care must be taken that the air is as dry as possible and does not strike directly on to the ignition plug, otherwise the moisture may short circuit it and prevent the spark. Where, however, a supply of air is not available, then the engine can be made to serve as an air pump, after the gas is shut off for stopping, when the mo-

valve box and the combustion chamber, to prevent the hot gases from damaging the valves and fittings on account of their not being water-cooled. The air receiver should have a capacity of about 15 cubic feet.

When the engine is connected up to the town's gas it is often started on this gas by means of a low-pressure multiple-impulse starter and then immediately turned on to the suction gas.

Although the compressed air sys-

tem (where no general supply is available) is more expensive than the other types, yet it is preferable to them, being more reliable and easier to manipulate.

Such firms as Messrs. Hornsby and Kynock have no standard method and fit either petrol or compressed air to suit the special conditions of each installation.

The question of starting naturally brings us to the question of turning

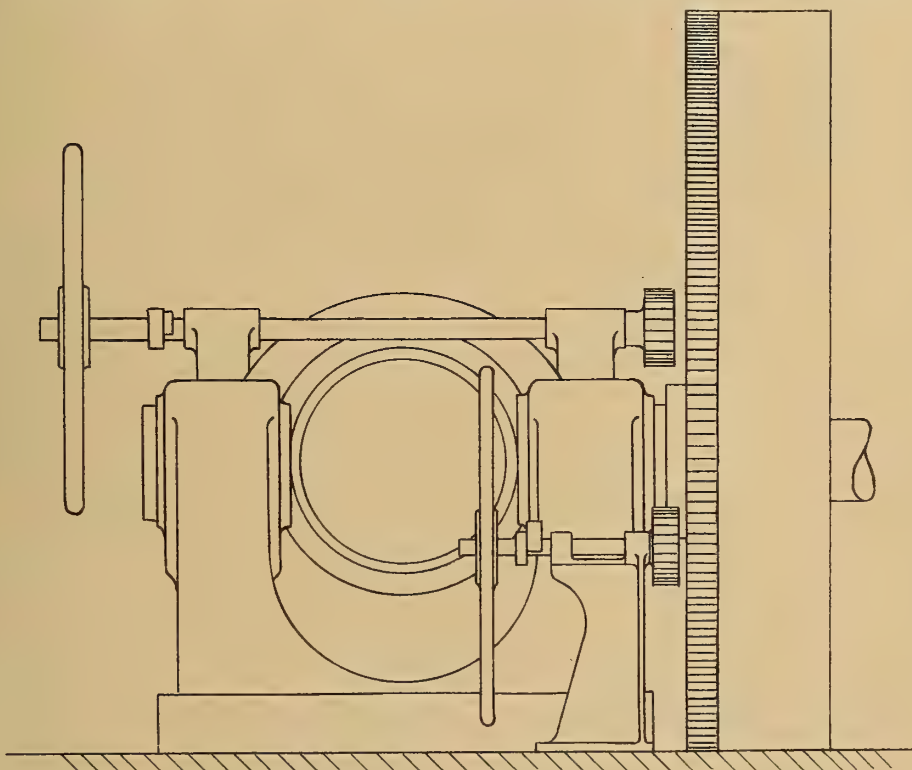


FIG. 15.—ACME AND CROSSLEY BARRING GEAR

the engine into the starting position, and as it is impossible, without much manual assistance, to turn an engine of this size, then some mechanical means are necessary whereby the attendant can do this himself. These are generally of two types. The first, consisting of a small spur wheel engaging into teeth cast on the outer flywheel rim, the power being applied by a polished hand wheel about 3 feet diameter and the second by a pinch bar, fulcrumed on a bracket fixed to the foundation, and engaging on holes cast in the side of the flywheel rim. The former is naturally the more effective and is fitted sometimes above the engine, as on the Acme, and sometimes to a bracket fixed to the foundations, as on the Crossley engines.

We give a sketch of the barring gear as fitted to the Acme and Crossley engines, and another showing the arrangement on the Tangye and National. With the spur-wheel type the wheel is pulled out of gear before starting the engine and is held there by the safety catch so as to prevent it fouling the flywheel when running.

The standard gear used on the Kynoch engines is the ratchet and pinion type, whilst Messrs. Hornsby

& Sons use the lever type, as on the National and Tangye engines.

Governors are universally of the vertical flyball type driven by skew gears off the cam shaft, except on the Crossley engines, in which it lies horizontal and is driven directly off the skew gear on the crank shaft. This latter arrangement is to avoid the shocks on the cam shaft, due to opening the exhaust valve, being transmitted to the governor.

Although the throttle governor is fitted to nearly all continental engines, so far it has obtained little or no hold in this country, where governors for horizontal engines (of this size) are all of the "hit or miss" type. As the gas valves on most engines, excepting the National and Crossley, are vertical, the duty imposed on the governor consists of rocking the shifting plate fixed to the end of the gas lever, so as to clear the gas valve when it is necessary to cut out an explosive. Fig. 9 shows the general arrangement as fitted to most engines.

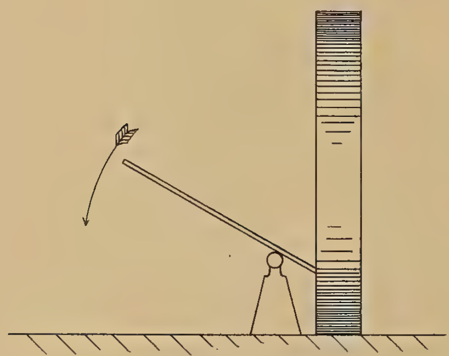


FIG. 16.—TANGYE BARRING GEAR

On the National and Crossley engines the gas valves are horizontal and operated in the same manner as on their small town gas engines. On account of the liability of this valve to stick with the tar, and most particularly after standing for some time, all wearing surfaces, levers, striking knife edges, must be made heavier than for town gas. Ample provision is made for oiling these valves, etc., to overcome this tendency to stick, and some time ago the National Company brought out a type of governor whereby the gas valve was operated directly from the cam without the usual knife edge plates intervening, the only duty performed by these latter being to move the gas roller along a stud to engage with the gas cam when it was required to take in gas. This governor was fitted to engines of 85 brake horse-power and up, but has since been discarded at least up to 100 brake horse-power and the old type reintroduced. The knife edge plates are generally made of special steel hardened and Fig. 17 shows those fitted to the National engine.

In the matter of lubrication alone, one finds that commendable progress has been made and the oil consumption reduced to about ½ gallon per day on an engine with ring lubricators to the bearings and ⅞ gallon on one with sight feed to the main bearings. Naturally much care must be exercised both in the class of lubricant used and in the method of applying it. Owing to the intense dry heat to which the cylinder is subjected, the oil used must have a high viscosity and burning point so as to resist this burning acting for as long a time as possible. Again, the carbon entering into the composition of such oils is deposited on the cylinder walls, piston rings, combustion chamber, sparking plug, etc., on account of this burning, and therefore to reduce this tendency as much as possible an oil containing as little carbon as possible is advisable. From numerous experiments it has been found that the clearer the oil the less carbon deposit is obtained and therefore, other things being equal, the oil having the lightest colour should be selected. On the Kynock, Ruston and Hornsby engines the oil is fed to the cylinder by a force pump. The pump plunger is operated directly by a cam on the cam shaft, and is set to deliver the oil during the suction stroke

of the engine. The National engines have a sight feed lubrication, whilst the Acme, Crossley and Tangye employ one mechanically driven, and arranged to give a constant feed till empty.

A hole is bored on the top side of the piston for allowing a supply to flow to the piston pin, and in addition a separate lubricator is generally fitted for this bearing. The crank pins are all lubricated by an internally grooved ring into which the oil drops and is thrown by the centrifugal force out to the bearing. Oil gutters are generally cut in the crank pin brass, but Messrs. Tangye cut

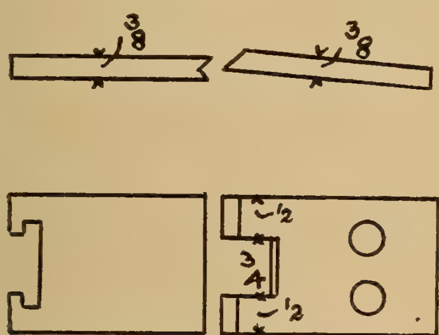


FIG. 17.—NATIONAL GOVERNOR PLATES

them on the pin itself. The grooved ring is either made of brass or aluminium, and practice is equally divided between feeding the oil from a sight feed glass oil cup and from a wick feed box.

The main bearings are mostly fitted with ring lubrication, a notable exception being the Tangye, with ordinary wick-box feed. Each bearing is generally supplied with two rings, those on the main bearings of the National engines being ½ inch broad and 5/16 inch broad on the outer bearing. These rings are generally made of flat sheet iron jointed as shown in Fig. 18, the spring of the ring keeping the joint in position. Oil throwers are usually turned on the shaft for preventing the oil running along. The cam shaft bearings, whilst generally lubricated by wick feeds, are in some cases, as notably the Kynoch engines, fitted with ring lubricators.

Very little attention is usually paid to collecting the waste oil from these bearings, it being usually allowed to run down into the foundations as on the Tangye engines, but in some instances it is led into the oil gutter running round the bed and on the National engine the shaft is reduced in diameter for a short distance at each end of the bearing so as to prevent the oil traveling along. The only engine we can recall having a tray fixed under the valve gearing is the Acme, and this effectively catches all the oil falling from the valves, levers, cams, etc. In most cases the purchaser is obliged to make a tray to lie on the floor for this purpose, but it is difficult to make it effectively catch everything on account of

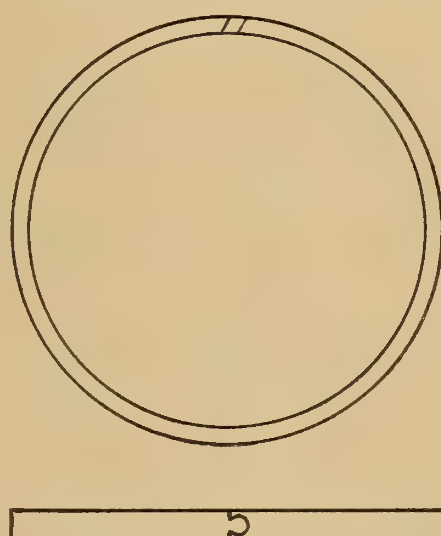


FIG. 18.—LUBRICATING RING

the pipes and foundations, etc., intervening.

It is only within recent years that makers have seen fit to abandon asbestos and other jointing material, which used to be such a nuisance on earlier engines, and now this material is only permissible where the pipes bolt to the engine. All other joints

are made metal to metal, which simplifies cleaning and examination to a great extent.

The speeds for ordinary work vary from 160 to 165 revolutions per minute, although the National Company's special mill-type engine for driving spinning machinery, looms, flour mills, etc., runs at 180 to 200 revolutions, and Messrs. Kynoch build only one type of engine suitable for ordinary or electric work and running at 170 revolutions. It is difficult to understand this latter policy, for the extra weights of the flywheel and crankshaft necessary for electric driving makes the Kynoch engine more costly than other standard ordinary-type engines.

With the exception of the water pipes, which are sometimes made of wrought iron, all the pipes are of cast iron to approximately the following sizes: water, 4 to 4½-inch bore; gas, 7-inch bore; air, 7-inch bore, and exhaust, 8-inch bore. Owing to the heat to which the exhaust pipe is subjected it is generally laid on rollers, so that it may expand freely. The necessity of this will be apparent when it is stated that it is a common occurrence for the pipe between the engine and exhaust box to expand ⅝ inch after a day's run. On the bend immediately beneath the engine, the National engines are fitted with expansion joints as shown on Fig. 19, and this takes up the expansion very effectively.

The gas-pipe bends should all be fitted with cleaning doors for cleaning the pipes without the necessity of dismantling them.

Where the engine is coupled up to the city gas as a standby, the pipes are generally arranged as shown on Fig. 20.

Sometimes the town gas is led separately into the gas cock as shown in Fig. 21, when a taper key is used and on Fig. 22 when a screw-down valve is fixed as on the Acme engine.

The meter should be of the dry type and of about 300 light capacity, with a 2½-inch to 3-inch pipe joining the anti-fluctuator to the engine.

It should be understood, however, that the town gas connection is not to be recommended, for if any stoppage arose, owing to ignorance or want of attention, the town gas is turned on, whereas, if no such standby were available the attendant

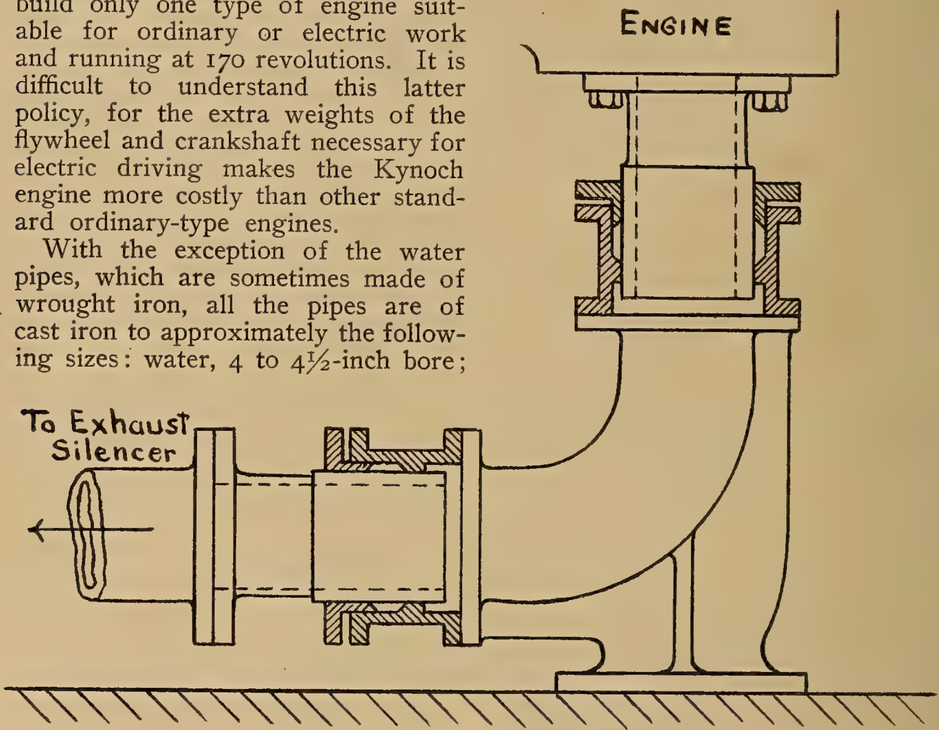


FIG. 19.—NATIONAL EXHAUST EXPANSION JOINTS

would pay more attention to the various matters requiring consideration.

For ordinary purposes the exhaust box usually consists of a rectangular cast-iron box about 2 feet diameter by 3 feet high. Where special quietness is essential special silencers are fitted to the end of the exhaust pipe, as shown in Fig. 23. The National silencer, as shown on Fig. 24, is designed on a similar principle and takes the place of the usual exhaust box.

Messrs. Crossley fit a small box about 21 inches square at the horizontal end of the exhaust pipe, the vertical pipe from which terminates in a Y piece, each branch carrying a special silencer.

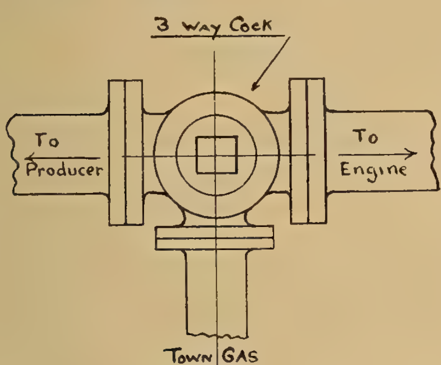


FIG. 20.—PIPE ARRANGEMENT WITH A THREE-WAY COCK

In some instances water is introduced into the exhaust pipe to cool the exhaust gases and thereby silence them, but this is hardly advisable unless special precautions are taken to treat all bends and surfaces against which the gas strikes, as the water forms acids with some of the constituents of the exhaust gases and this quickly eats away the metal. We have seen a pipe 1½ inches thick eaten away in this fashion within a year.

Where steam can be used with advantage it can be obtained by means of a Wilson exhaust boiler, whereby 2 to 2¼ pounds of water can be evaporated per hour for each horse-power given out by the engine. As the steam is wet it is useless for driving engines, but still there are a great many processes requiring steam which does not require to be particularly dry, and a large number of these boilers are in successful operation.

Air silencers are more or less of a standard type, consisting of a cast-iron chamber filled with rope and placed alongside the engine. Messrs. Crossley, however, carry the pipe outside to the atmosphere and place a small receiver near the engine, this arrangement working in conjunction with their starter, as explained above.

The quantity of water to be stored for cooling the cylinder depends on the position, the shape and the arrangement of the tanks, for the more cooling surface there is exposed to the atmosphere the less water requires to be stored. The cylindrical tanks, for so long used on gas engines, are generally abandoned (for this size of engine) in favour of a rectangular tank, for though exposing a greater cooling surface than the latter they are more expensive to construct and erect. Thirty gallons per brake horse-power is usually sufficient. It is imperative that the rectangular tank be erected with its base at least 4 feet above the center line of the engine cylinder, but preferably on the roof of the engine house, where the cold air can circulate freely around it, and the inlet and outlet pipes should be at opposite ends. Where the cooling water is run through the engine and then to waste, from 3½ to 5 gallons per brake horse-power per hour are sufficient for this purpose.

With the increasing weight and cost of the driving belt, due consideration must be given to its treatment, and the method of working with a fast and loose pulley is not to be recommended. So many excellent friction clutches are now available at reasonable prices that they are generally adopted in most installations, both on account of their many

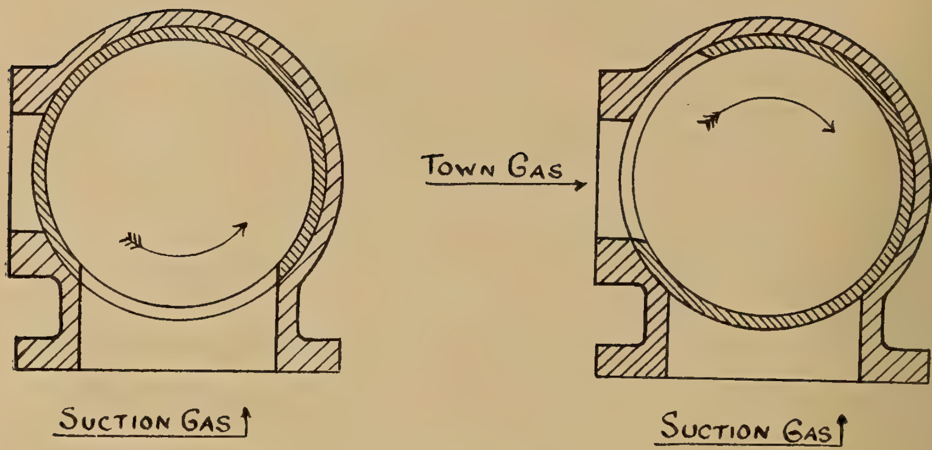


FIG. 21.—GAS COCK

advantages as well as the saving of the belt. The clutch makers are now able to supply a clutch specially suitable for gas-engine driving and generally a size or two larger than for ordinary drives. Whether the clutch should go on the engine or counter shafting is a matter to be decided for each individual case, bearing in mind the following rules: If, say, two engines are driving into one shaft and one is sometimes run without the other, then the clutches must go on the engine shafts; or, if one engine drives, say, two lines of shafting or one line of shafting and a dynamo, both units not always being required together, then the clutches

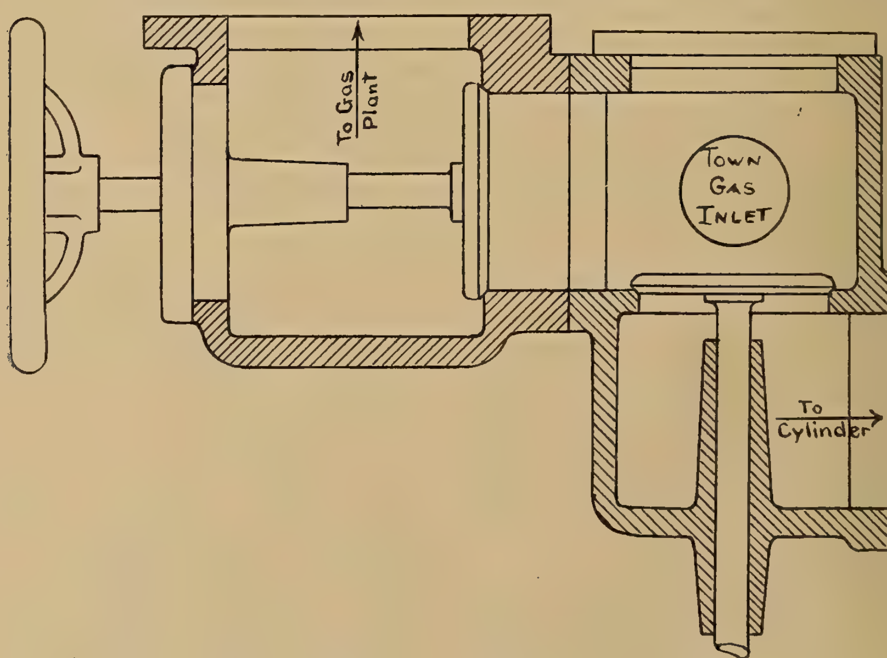


FIG. 22.—ACME GAS COCK AND VALVE

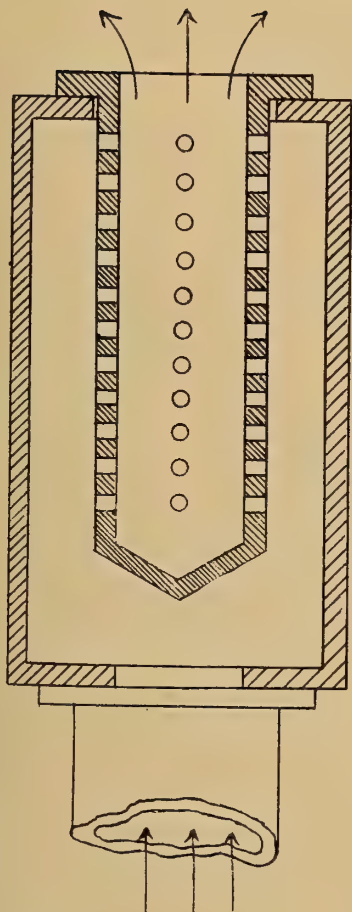


FIG. 23.—ACME EXHAUST SILENCER

must go on the counter shaft. This is necessary, because the part of the clutch running on the gun-metal bearing and carrying the pulley must always be made to revolve when the shaft is stationary, so that the belt pull is distributed evenly over the bearing. If the shaft revolves and the bearing and pulley were stationary, then the wear on the bearing, due to the pull, would be in that particular point against which the shaft was pressing. The diameter of the counter shaft at the clutch bearing should be about 5 inches.

As competition becomes keener and makers are perforce endeavouring to give purchasers the best possible value for their money, then we may reasonably expect this size of engine to assume, as has been done by the smaller engines, a practically stand-

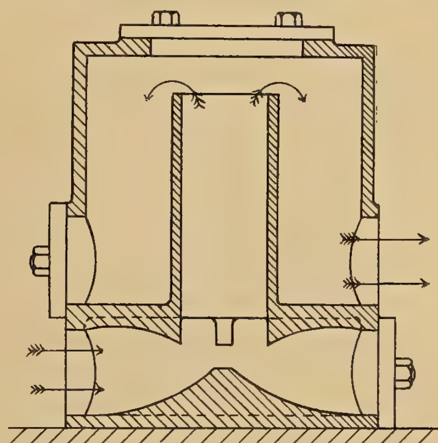


FIG. 24.—NATIONAL EXHAUST SILENCER

ard design, as might be indicated generally by the following specification:

Cylinder and bed cast in one, with separate liner and back end. Angled main bearings with ring lubricator, single flywheel and outer bearing, with barring gear of the Acme and Crossley types. Oil gutter round frame. Balance crankshaft and continuous lubrication to pin. Vertical valves with "hit or miss" governor. Completely enclosed skew wheels and three bearings for cam shaft. Fixed type magneto ignition. Special exhaust silencers. Piston without water-cooling.

SWEDISH HYDRO-ELECTRIC POWER-PLANTS

By John Geo. Leigh

OWING to circumstances discussed in a previous article*, industrial conditions in Sweden were much less affected than were those of other countries by the many revolutionary changes which followed Watt's great discovery and the ever-expanding use of steam as a motive power. Elsewhere throughout the world, successive generations have been taught to regard steam as the one autocrat of industry whose sway could never be challenged, the steam-engine as a thing of perfection, and coal as its indispensable fuel. All these axioms suffered a severe shock when, but a few years ago, electric energy was subjected to practical control to-day, moreover, their very life is threatened by a working alliance between the same, still in some degree, imperfectly-understood power and water—the oldest, best-understood and mightiest of initial sources of energy.

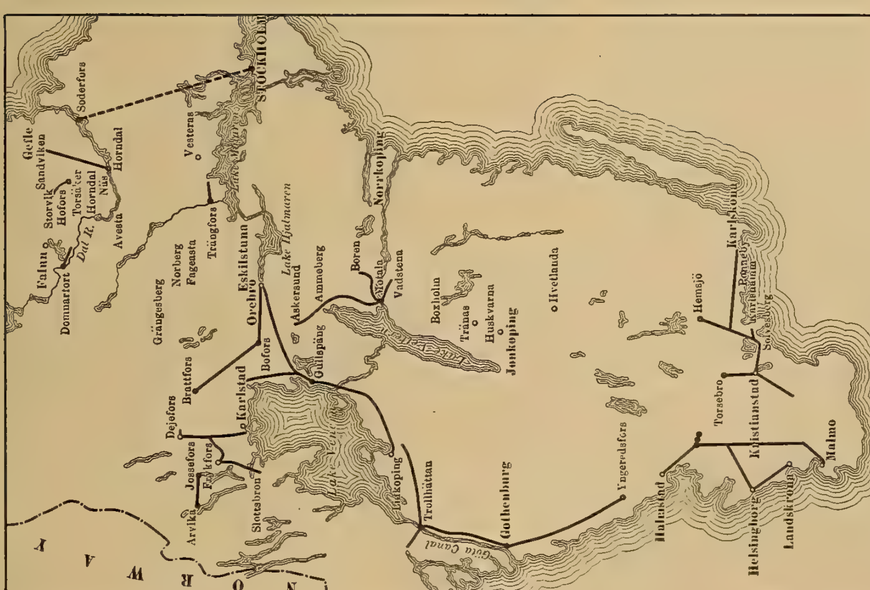
Youthful as this compact is, we have seen enough of its possibilities to recognize that, wheresoever available, water power and electric energy combined offer a force superior to all others in economy, efficiency and adaptability to the most diverse of industries. Owing to abundance of water and scarcity of coal, Sweden was naturally predestined to larger dependence on the one than on the other, with the result that, even in the heyday of the now passing "Age of Steam," and notwithstanding a wealth of alternative fuels in the shape of peat and timber, water always continued to play quite as effective a part in the industrial development of the nation as did steam.

It is, however, only within the past few years that companies have been established and hydro-electric plants erected for the purpose of supplying power to a large number of consumers spread over considerable areas. With few exceptions, the earlier installations—that is to say, those completed during the final decade of the last century—were designed to meet the requirements of a single large works or mining corporation or of a small group of contiguous industrial establishments. Even the towns which during this period availed themselves of water-generated electric energy were comparatively few. This may appear somewhat strange to those who remember the readiness with which the urban communities of Sweden adopted electric lighting. As a matter of fact, however, the one circumstance naturally followed the other. When long-distance transmission of energy came to the fore, nearly all the towns already possessed electricity works, generating current by steam or other heat-motors, and controlled either by the communities themselves or by concessionary companies.

With the new century came a widespread and ever-increasing demand for more economically-produced power, with the result that there are now very few of the old steam centrals which have not been enlarged or supplemented by energy derived from waterfalls. During recent years, moreover, the capacity of most of the older hydro-electric stations has been considerably augmented, with a view, ofttimes, to

* "The 'White Coal' of Sweden," Cassier's Magazine, February, 1909.

TRANSMISSION LINES OF THE VERMLANDS COUNTY ELECTRICAL SUPPLY CO.

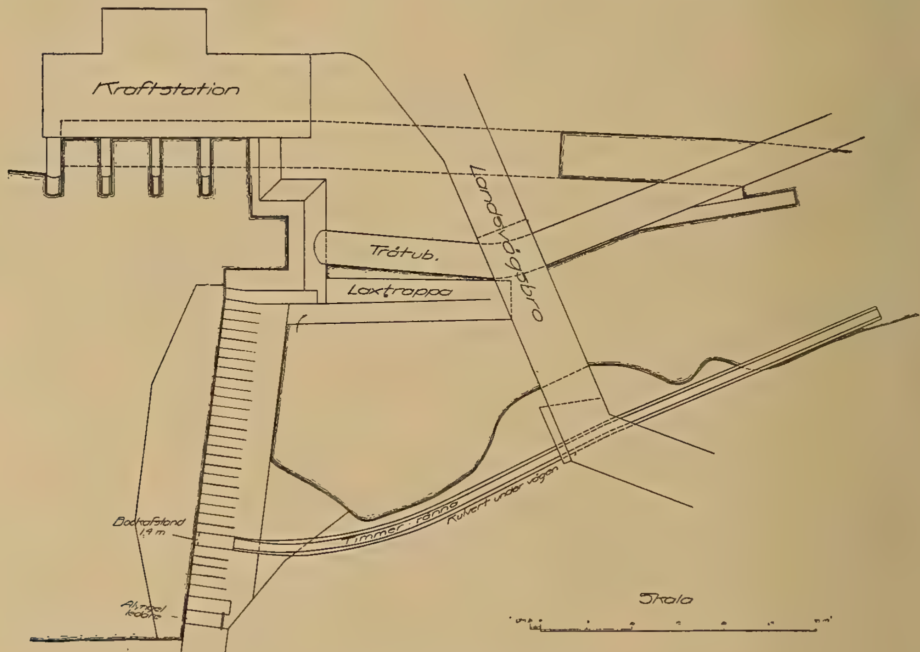


SOME HYDRO-ELECTRIC STATIONS OF CENTRAL AND SOUTHERN SWEDEN

meeting the requirements not only of the original owners, but also of neighbouring industrial undertakings. Concurrently, also, there have come into being a number of companies distributing power to communities and consumers over more or less extensive areas.

In Central and Southern Sweden the more important of these power-distributing companies are the Gullspang-Munkfors, with a capacity of 16,000 horse-power (shortly to be increased to 25,000 horse-power), redsfors, 8,250 horse-power, 40,000 volts. In Norrland there are many similar companies, including the Ange, 1,125 horse-power; Boden, Ljusa power-station, 1,100 horse-power; Örsa, 220 horse-power; Ostersund-Hissmofors, 1,800 horse-power, 10,000 volts; and Wii, Sundsvall, 1,200 horse-power.

The most notable stations at present in course of construction and nearing completion are that at Trollhätten for the Royal Trollhätte Canal and Waterworks, which will



PLAN OF THE FRYKFORS POWER PLANT

40,000 volts; Hemsjö, 3,500 horse-power (to be increased to 10,000 horse-power), 40,000 volts; Jossefors, 1,800 horse-power, 7,000 volts; Motale River, 1,800 horse-power, 20,000 volts; Orebro, 6,000 horse-power, 20,000 volts; Stenkvill-Klinte, Hvetlands power-station, 1,300 horse-power; Storvik, Torsäker power-station, 2,200 horse-power; Trängfors-Vesteras, 1,875 horse-power, 14,000 volts; Vermlands County, 6,000 horse-power, 34,000 volts; and Yngehave an immediate capacity of 40,000 horse-power, to be later increased to 150,000 horse-power, with a tension voltage of 40,000, and those for the South Swedish Power Company, at Mäjenfors, Bassalt, and Upper and Lower Knäred, with an aggregate capacity of 21,000 horse-power, 50,000 volts.

The undertaking of the Vermlands County Electrical Supply Company is interesting, not only on account of its extent, but also because it was

TIMBER CONSTRUCTION FOR COFFER-DAM. FRYKFORS POWER STATION

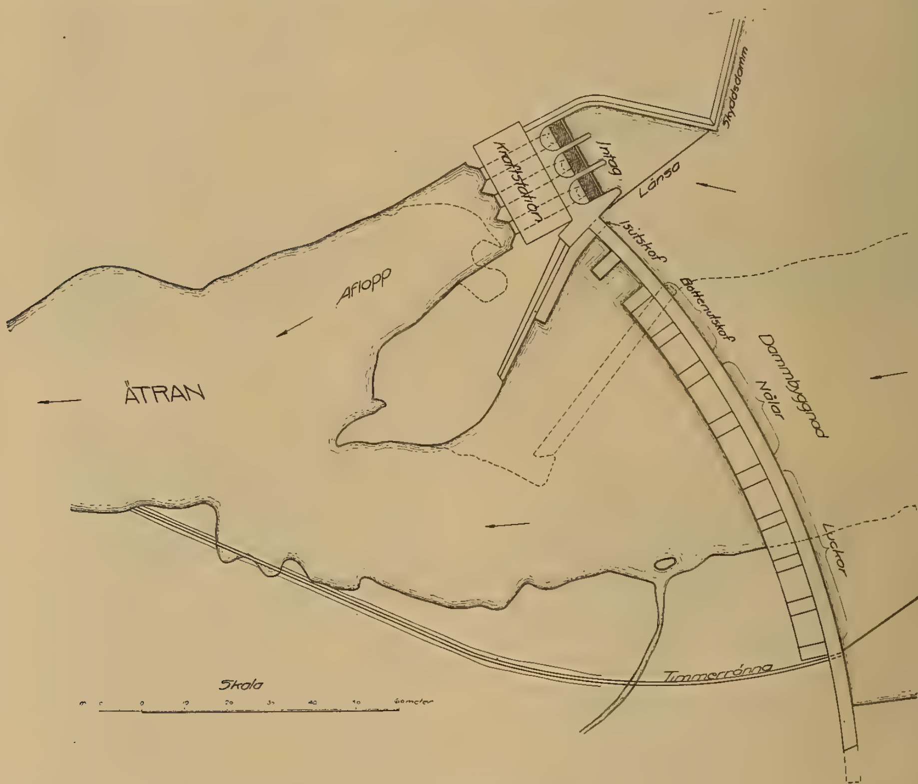
BUILDING THE COFFER-DAM. FRYKFORS POWER STATION

THE FRYKFORS POWER STATIONS, SEEN FROM BELOW

THE COFFER-DAM FLOODED. FRYKFORS POWER STATION

the first in Scandinavia to use a line voltage as high as 34,000 volts. It thus demonstrated the facility with which, with the use of high-transmission voltages, waterfalls far removed from the points to be supplied with power can be utilized, and, by its system, that power stations situated a considerable distance apart can be linked up in parallel on the same transmission lines. The company rents the two stations at Frykfors and Dejefors, with the pertaining transmission lines, and now proposes to link with these a third power station at Edsvalla. The manner in which the first-mentioned station assists the second is well worthy of note.

The power station at Dejefors, on the Klar river, has during a period of about two weeks each year a very low water supply, and also lacks in the neighbourhood natural reservoirs which might be utilized for storage purposes. Above the station at Frykfors, on the other hand, is a series of lakes, which can be drawn upon whenever required, and, as a matter of fact, during the fortnight's draught at Dejefors, supply the entire power. In other words, thanks to its storage resources, the Frykfors station can always be depended upon to take the peaks of the load.



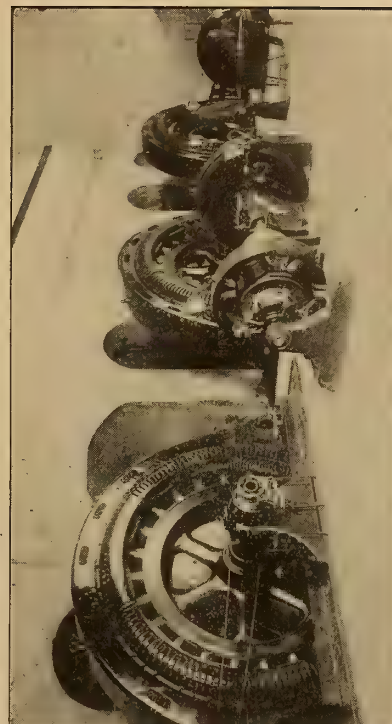
PLAN OF THE YNGEREDSFORS POWER PLANT

So far as equipment is concerned, the two power-stations are very similar. At Frykfors, which has a fall of about 27 feet, with a minimum discharge of 882 cubic feet per second, the four turbo-generator sets, with an aggregate capacity of 4,000 turbine horse-power, have vertical shafts. The turbo-generators are double-staged and the exciter turbines single-staged, all being directly

VIEW OF THE YNGEREDS FALLS

OUTLET TUNNELS FROM POWER STATION. DAM IN COURSE OF ERECTION. YNGEREDS FALLS

YNGEREDS FALLS. THE DAM, SEEN FROM BELOW

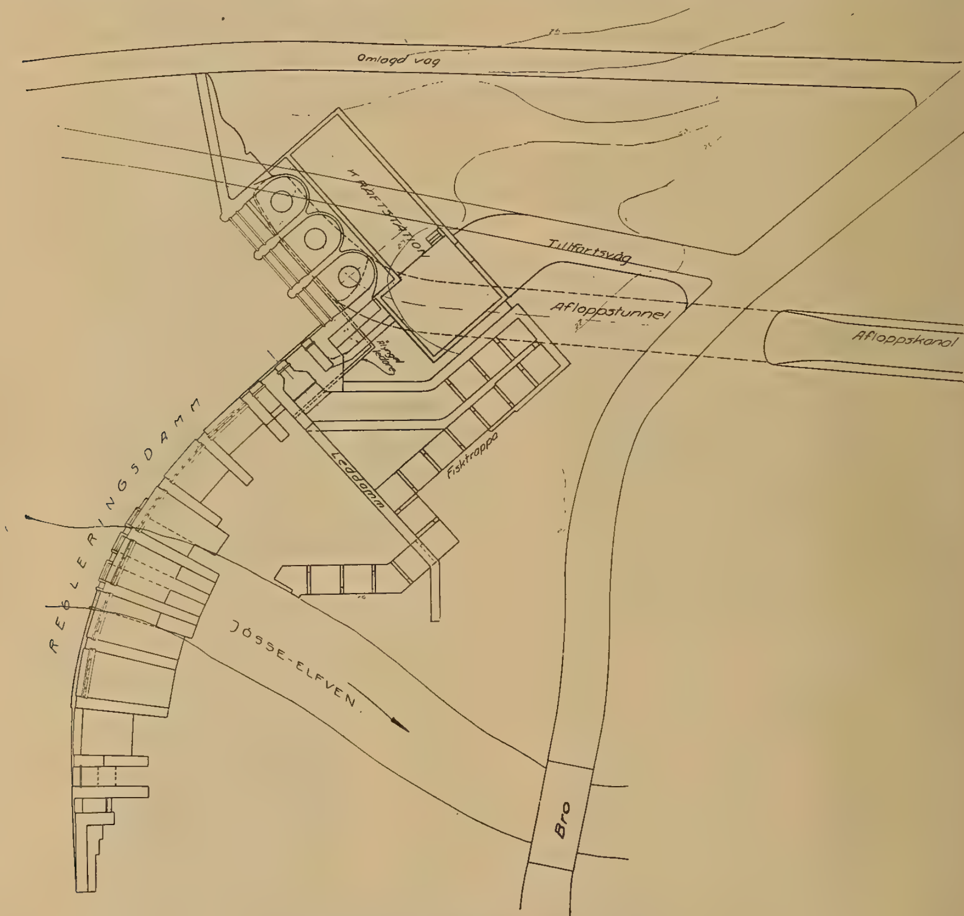


YNGEREDSFORS POWER STATION. EQUIPMENT BY THE GENERAL ELECTRIC MFG. CO., OF SWEDEN. VESTERAS

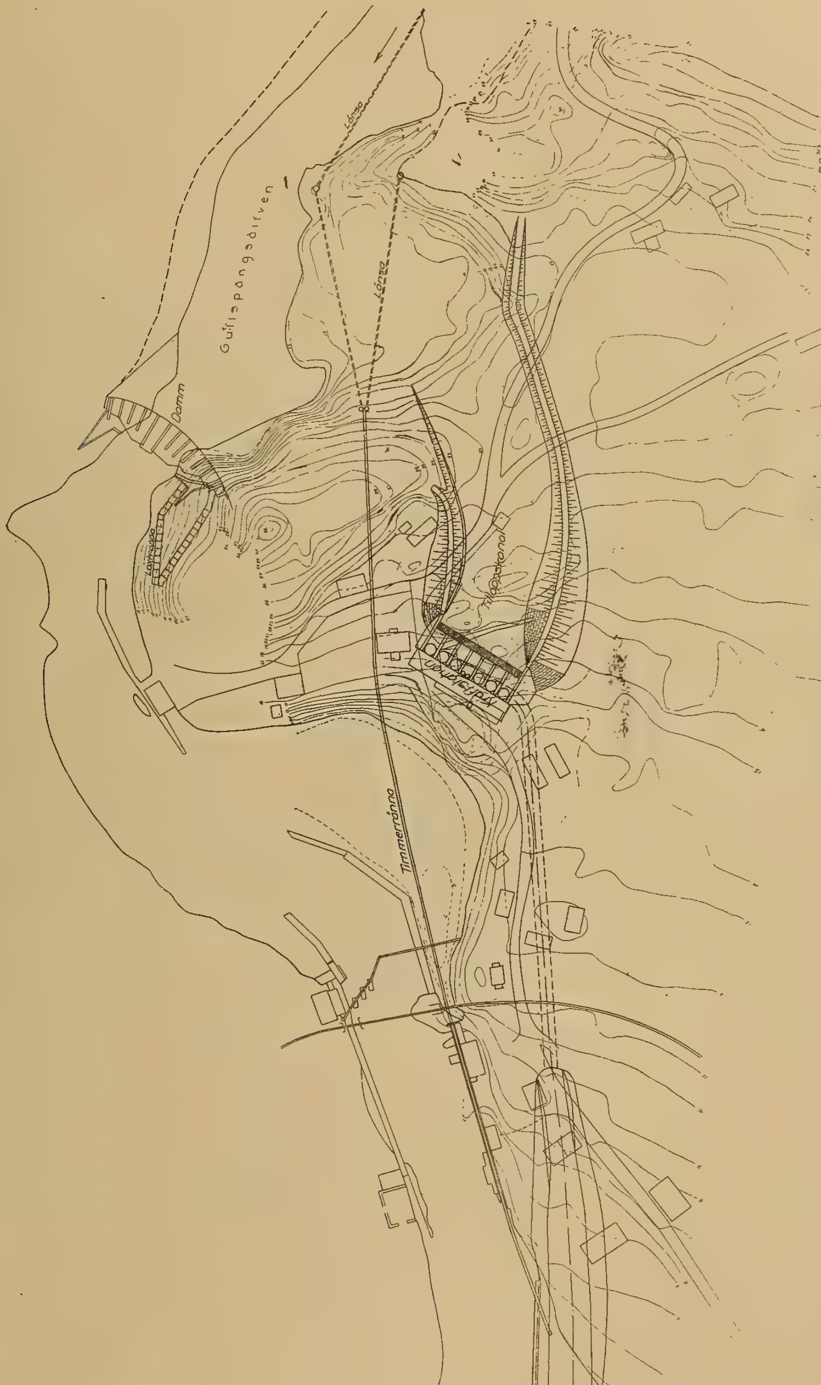
coupled with their respective units in the generator-room. The latter also contain automatic governors for the turbines and low-voltage instruments, the transformers and high-voltage apparatus being placed on an upper floor. The cost of the buildings was £35,360, and of the equipment, £12,700, the total being equivalent to about £12 per horse-power. The construction of the dam, illustrated in the accompanying series of photographs, involved considerable difficulty, a coffer-dam, 32 feet high, having first to be erected, in order to maintain the water-supply to an already existing power-plant.

At Dejefors, where the fall is about 30 feet and is to be increased to 36 feet, there are five turbines with horizontal shafts. The generator voltage is 2,000 volts, which is transformed up to 34,000 by three-phase transformers. In the machinery halls all the instruments and apparatus are placed in the 2,000 volts circuit, the high-tension equipment being contained in separate room, with the respective cables and apparatus in fire-proof cells. Thus all possibility of short circuits or faults between the different phases is avoided.

From both stations transmissions lines are carried to the city of Karlstad, the electricity works of which



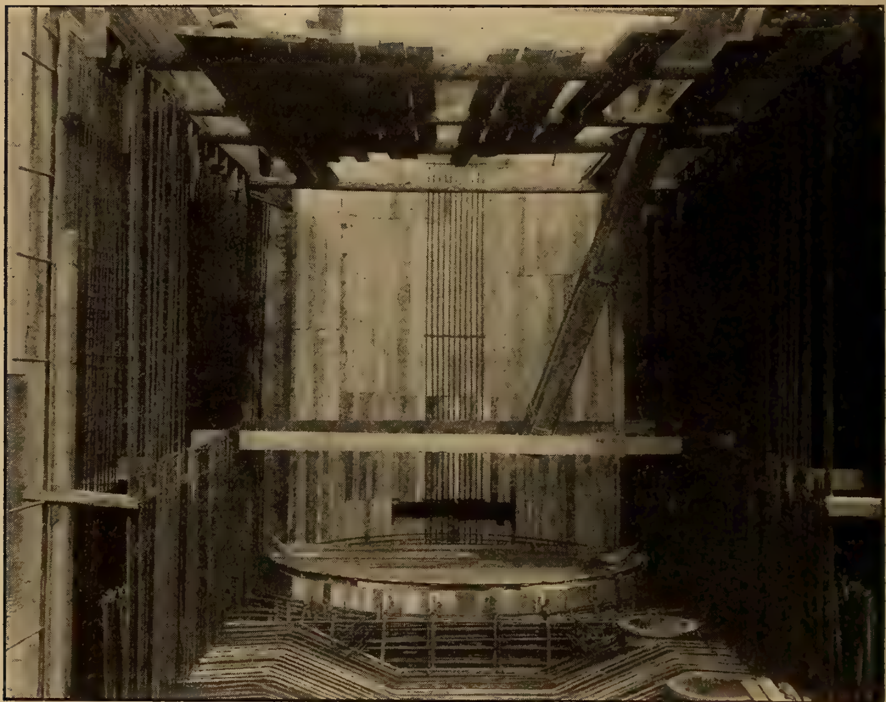
PLAN OF THE JOSSEFORS POWER STATION



PLAN OF THE GULLSPANG POWER PLANT

are solely supplied by power from these sources. Other considerable consumers of energy generated by the Vermlands Company are paper and pulp mills at Dejefors, Klarafors, Edsvalla and Slotsbron.

In 1905, just after the inauguration of the Dejefors-Frykfors undertaking, the Yngeredsfors Power Supply Company was organized, with a view to the utilization of waterfalls on the Atran river and the transmission of hydro-electric energy, over a distance of about 55 miles, to cotton and paper mills and other industrial establishments at Molndal, Krokstatt, Garda and adjoining suburbs of Gothenburg. The Yngereds falls are about 60 feet in height, and the plant consists of a dam, with a power-station at one end, to which the water is admitted directly. There are three turbines, each rated at 2,750 horse-power, with horizontal shafts, direct-coupled, and mounted in open circular chambers. The power-station, erected in 1907, is a two-story building, with roof and flooring of reinforced concrete. In the first floor are installed three generators and two turbines, directly coupled with exciters. These generate at 4,000 volts, and each has three single-phase transformers to raise the pressure up to 40,000 volts for the line. A tenth transformer has also been installed, so arranged that it can be readily coupled in should a fault occur on any one of the others. The transformers, each in a separate fire-proof cell, and the high-voltage instruments occupy the upper story of the building. In addition to the places already mentioned, the current is carried to the city of Varberg, where a sub-station, equipped with steam-turbines, has been erected, with a view to meeting



GULLSPANG POWER STATION. TURBINE CHAMBER OF REINFORCED CONCRETE, FOR A FLOW OF 706 CUBIC FEET PER SECOND

any demand caused by failure of the water-supply. The cost of the Yngeredsfors power-station, almost equally divided between buildings and machinery, was £58,560, corresponding to about £8 per horse-power.

From the power-station at Jossefors, completed last year, non-transformed current of 7,000 volts is transmitted to a neighbouring factory and the township of Arvika, nearly five miles distant. The fall of water varies between 24½ and 26 feet, and the maximum discharge is 277 cubic feet per second. The three turbines are double-staged with horizontal shafts and mounted in open chambers; have an aggregate capacity of 1,800 horse-power, and are

OUTLET UNDER THE GULLSPANG POWER STATION. TOTAL LENGTH OF TUNNEL, 820 FEET

DISTRIBUTION BASIN OF THE GULLSPANG POWER STATION

Six systems, with a capacity of 706 cubic feet per second each. Two exciter systems, each with a capacity of 35 cubic feet per second. Fall, 65.6 feet, with facilities for increase to 74 feet.

GULLSPANG DAM, SEEN FROM BELOW

directly coupled with the generators. In the generator room are mounted three generators, two exciters, turbines for the latter fed by a special water tube, automatic turbine-governors, switch board, etc. The buildings cost £17,680 and the equipment £6,630, which, for the 1,700 horse-power actually in use, corresponds approximately to £14 5s. per horse-power.

To utilize the fine volume of water coming over the Gullspang Falls there has recently been completed a power-station which promises to be a worthy rival to Stockholm and Trollhättan. The fall at Gullspang is about 65 feet and the minimum discharge 1,590 feet per second, the maximum energy available being 25,000 horse-power. The general arrangement of the station will be readily seen from the accompanying series of photographs. From the dam the water is taken through a short hydraulic canal to a distribution basin, built together with the power-station. At present there are installed four units of 3,000-4,000 horse-power each, one of 4,500 horse-power, and two exciters of 225 horse-power. The generator voltage is stepped up to 40,000 volts. The extent of the area of supply may be gathered from the fact that the total length of power mains connected with the station will exceed 200 miles.

GENERATOR ROOM OF GULLSPANG POWER STATION, SHOWING 4,000-H. P. GENERATORS, 5,000 VOLTS, TURBINE GOVERNORS, WITH RELIEF HOLDERS, AND 20-TON TRAVELING CRANE

In the following map are shown the primary transformer stations and transmission lines of a portion of the extensive system of the Hemsjö Power Company. This undertaking may be said to have been inspired by its managing director, Dr. Alfred Ekstrom, a well-known electro-technical expert, who in 1905 conceived the idea of gathering under common control the water-power in the eastern part of the province of Skane and the adjoining province of Blekinge, with a view to serving

GULLSPANG POWER STATION. ROAD BRIDGE OF REINFORCED CONCRETE

them with electric energy under the most economical conditions. The company was incorporated in 1906 with a capital of about £77,000, since increased to £276,000, and at once proceeded to acquire waterfalls suitable for its purpose. Among others, it secured the most powerful falls in the Ronneby river, in the Morrum river, which takes its water from Lake Asen, with an area of 58 square miles, and in the Helga river, below Lake Mockeln, which has an area of 17.3 square miles. The first power-station opened by it was that of Upper Hemsjö, with a capacity of 3,000 horse-power, in 1907; and this was followed by the completion in rapid succession of other stations—Lower Hemsjö, 2,500 horse-power; Fridefors, 3,000 horse-power; and Ryd, 2,300 horse-power. A further supply of 3,000 horse-power will be immediately available by the opening of a large station at the Torsebro Falls.

The electrical equipment of the Upper Hemsjö station is almost exclusively of foreign origin. All the later installations, however, connected with the system are of Swedish design and construction, most of the plant and apparatus having been supplied by the Amalgamated Electric Company of Stockholm. The latter's deliveries of larger transformer include:

	Total KW.
Axeltorp transformer station:	
One three-phase transformer of 300 KW.	300
Ifö transformer station:	
Four single-phase transformers of 370 KW. each.	1,480
Solvesborg transformer station:	
Two three-phase transformers of 100 KW. each	200
Solvesborg secondary transformer stations (2):	
Four three-phase transformers of 25 KW. each	100
Kristianstad transformer station:	
Seven single-phase transformers of 300 KW. each	2,100
Central station of the municipality of Kristianstad:	
One three-phase transformer of 300 KW.	300
M. Pehrsson's Flour Mill Co., Ltd.:	
Two three-phase transformers of 300 KW. each	600
Scanian Wool Manufacturing Co., Ltd.:	
Two three-phase transformers of 300 KW. each	600
Maltesholm transformer station:	
Four single-phase transformers of 370 KW. each	1,480
Torsebro power station:	
Three three-phase transformers of 880 KW. each	2,640
Total, 30 transformers, with an aggregate capacity of	9,800

The complete electrical equipment of the Torsebro power-station has been manufactured and supplied by the same company, as also has that for all the secondary transformer

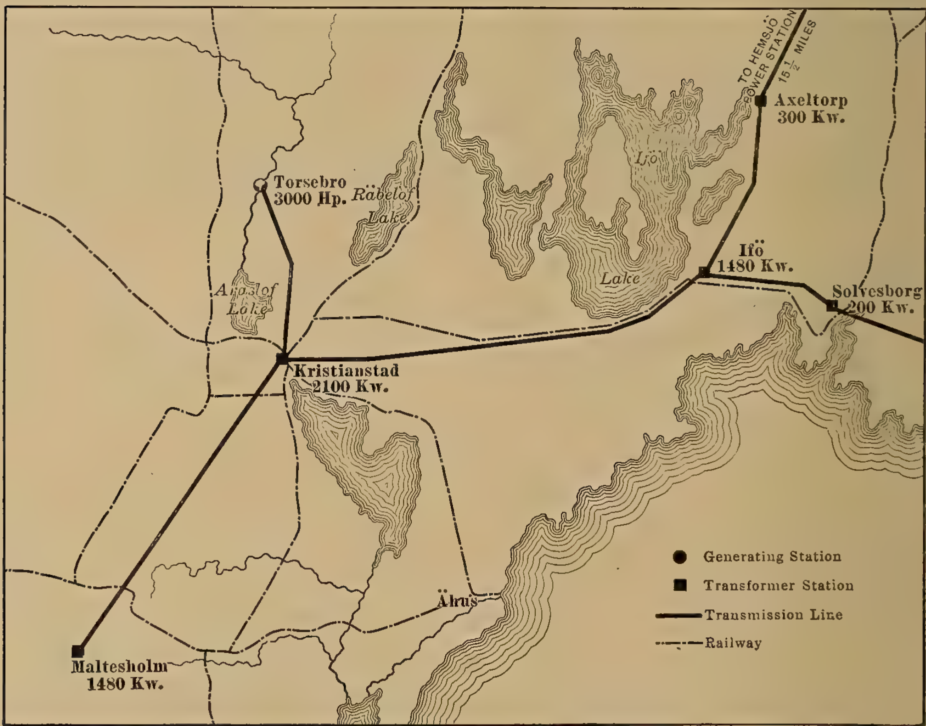
stations for 5,000 and 1,700 volts primary tension. The plant at Torsebro includes three three-phase generators, each of 880 KW. capacity, at 6,600 volts, 50 cycles and 214 revolutions, direct-coupled to horizontal shaft turbines, each of 1,000 horsepower normal rating; and two exciters, each of 42.5 KW. at 550 revolutions and 125 volts, direct-coupled to turbines of 65 horse-power normal rating each. In construction and installation the station satisfies the most exigent requirements of modern practice. Among the photographs illustrating the Hemsjö Company's undertaking will be observed one of a railroad crossed by a transmission line of 40,000 volts. The concrete bases of the steel-towers are, it will be noticed, of unusual height, a special precaution in the interests of public safety arising out of the possibility at faults of danger of contact with the bare metal.

Electric energy has been supplied by the Hemsjö Company since the end of 1907 to the municipality of Kristianstad and a number of industrial establishments in and around that town, and more recently to the local authorities of and many private consumers in Karlshamm, Karlskrona, Solvesborg and neighbouring county boroughs and rural districts. With the completion of its system and that of the South Swedish Power Company, which is exploiting waterfalls on the Lagan river and linking together Halmstad, Helsingborg, Landskrona, Malmo and other large centres of population and industry in Halland and western Skane, there will be but few districts in the three southernmost provinces of the peninsula lacking well-ordered and economical opportunity of utilizing hydro-electric energy for the furtherance of agricultural or manufacturing industries.

One of the most recent and complete installations in Norrland is that belonging to the Greninge Works Co., Lim., owners of extensive saw and pulp mills and charcoal works. The company also possesses a valuable asset in the Forsse waterfall, with a head of 62 feet, formed by the Faxe river, just above its confluence with the Angerman. For the

UPSTREAM VIEW OF DAM AT GULLSPANG POWER STATION. HEIGHT FROM GROUND LEVEL TO TOP, 65½ FEET

purposes of its own works, it has used for several years past part of the energy derivable from this fall. Last year, however, consequent upon arrangements with other industrial establishments, a new power-station was completed, designed to utilize, as required, the whole of the available power, namely, 10,000 horse-power. The station, a handsome five-story building of stone and iron, with wooden roof, was planned by the Amalgamated Electric Co., Lim., who 800 horse-power to Kramfors, about 34½ miles distant; 400 horse-power to Franö, 37½ miles; and 600 horse-power to Svano, 40 miles, and thence distributed to a number of industrial enterprises. Each generator has a normal rating of 2,150 KW., at 50 periods and 5,000 volts, and is direct-coupled to a double-main turbo-generator of 2,500 horse-power at 300 revolutions. The exciter current is furnished by two direct-current shunt-wound generators, each of 130

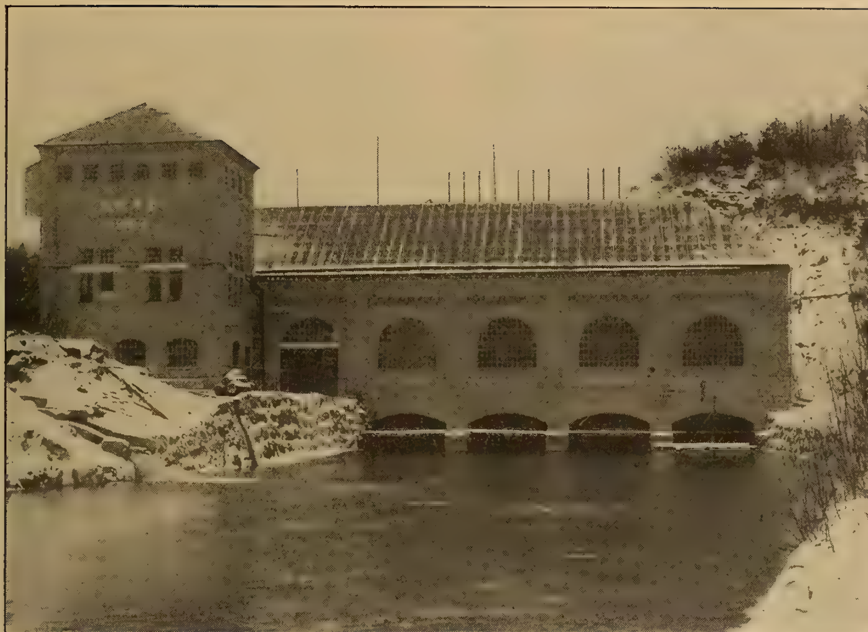


TRANSMISSION LINES OF THE HEMSJÖ POWER SUPPLY CO.

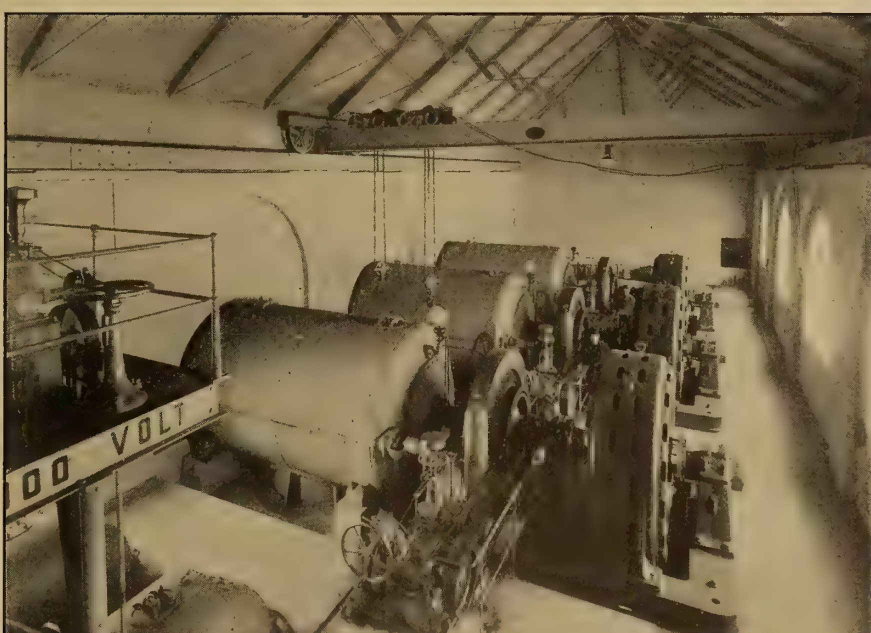
also supplied its entire plant and that of the transformer stations, including transmission lines.

The Osterforsse station is at present equipped with two units (to be later increased to four) of an aggregate capacity of 5,000 horse-power, of which about 2,000 horse-power are used around the station, the remainder being transmitted to transformer stations at pulp-mills along the Angerman, viz., about KW. capacity, direct-coupled to turbines developing 200 eff. horse-power at 600 revolutions per minute. The generator voltage is raised by means of oil-insulated, water-cooled single-phase transformers to 40,000 volts. At present there are two banks of transformers, one for each generator, and each consisting of three single-phase transformers of 720 KW. capacity.

Three rivers are crossed by the



POWER STATION OF THE HEMSJÖ POWER SUPPLY COMPANY



THREE-PHASE, HIGH-TENSION PLANT. HEMSJÖ POWER STATION

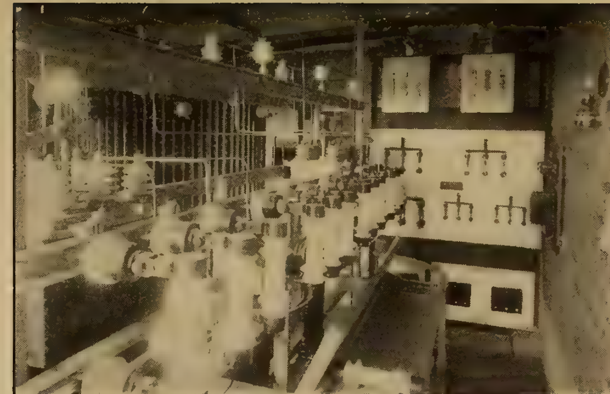
transmission line, the Faxe, with a span of 410 feet; a tributary of the Angerman, with one of 393 feet; and the Angerman proper, with one of 1,083 feet. As the Angerman at this point is navigated by large ships, steamers, as well as sailing vessels, it was laid down in the concession that the wires must be at least 131 feet above the water level and that traffic should not be interfered with more than an hour. These conditions and the considerable span called for special arrangements in effecting the crossing and somewhat unusual precautions to insure a perfectly reliable construction. On each bank of the river is an iron framework mast, on the top of which are fitted, at a height of 121 feet, two large rope pulleys, each supporting a steel-wire rope of 1 inch diameter. To raise these ropes from the river-bed and stretch them between their respective mast-heads was, with the aid of a powerful capstan, operated by an electric motor, the work of less than ten minutes.

The steel ropes are anchored in the rock by means of springs which compensate for, as nearly as possible, the sag on the ropes, amounting at the maximum to about 46 feet, caused by variations of the temperature and larger changes in the wind pressure. From these ropes are suspended at intervals of about 154 feet six angle-iron frames, to which are fastened the insulators supporting the tension-carrying copper wires. The frames are hung by means of steel wires of different lengths, shortest at the middle of the span and longer at the river sides, with the result that the transmission lines are practically horizontal all the way. The advantage of this arrangement is that the tension-carrying wire is not subjected to large mechanical stresses, as is often the case with ordinary spans.

TRANSMISSION LINE OF THE HEMSJÖ POWER SUPPLY CO. A RAILROAD CROSSING

For the somewhat hazardous task of mounting the iron frames with the insulators, a volunteer was found in the person of an agile young sailor. A special truck or wagon, man-

STANDARD TRANSFORMER STATION OF THE HEMSJÖ POWER SUPPLY CO.



INTERIOR OF TRANSFORMER STATION. HEMSJÖ POWER SUPPLY CO.

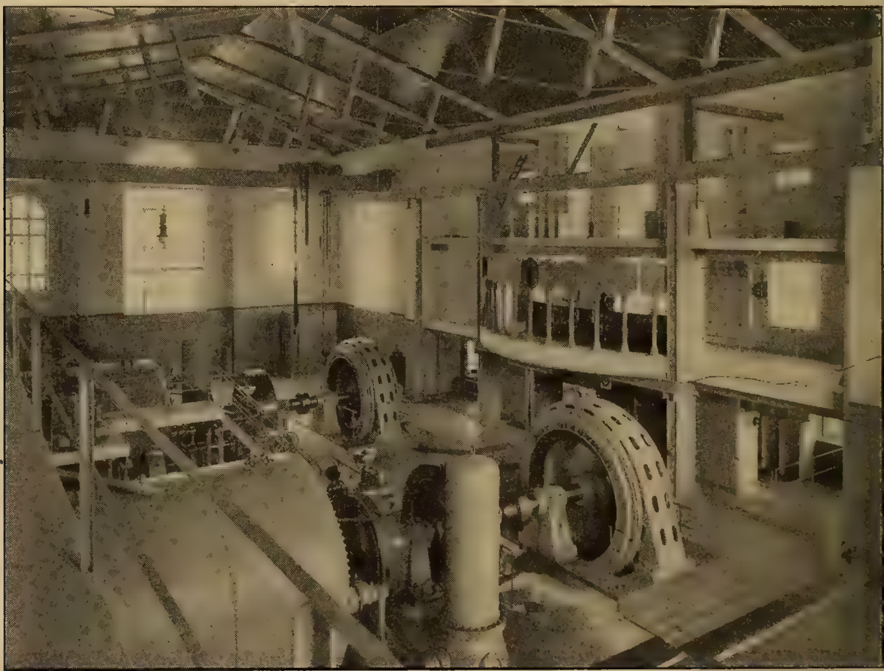
40,000-VOLT, THREE-PHASE, OIL-COOLED TRANSFORMERS IN KRISTIAANSTAD. HEMSJÖ POWER SUPPLY CO.

40,000-VOLT APPARATUS, KRISTIAANSTAD TRANSFORMER STATION. HEMSJÖ POWER SUPPLY CO.

euvered by ropes from the two towers, was constructed, and from this was suspended a basket, capable of being raised or lowered at will, so that the sailor-fitter could come on a suitable level with the insulators.

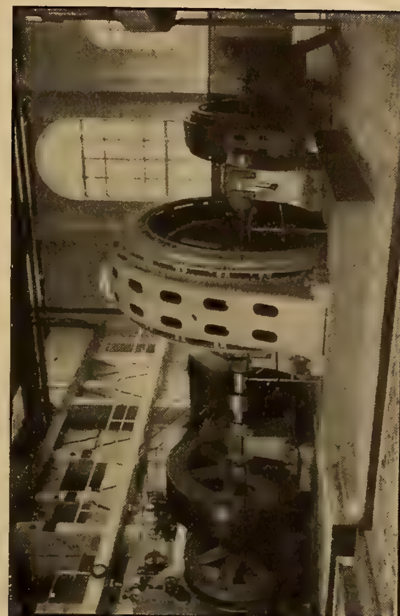
Still nearer the Arctic circle is the power-station at Finnforsen, on the Skellsfte river, the electrical equipment of which was entrusted, with very satisfactory results, to the Luth & Rosens Electrical Company. The falls are capable of yielding 12,000 horse-power, but at present only a third of that amount is installed. The electrical plant includes four three-phase 50-cycle generators, each of 900 KW. capacity, 2,200 volts. These are direct-coupled to 1,000 horse-power turbines. Exciting current for the alternators is supplied by two shunt-wound direct-current generators, one belt-driven from one of the alternators, while the other is coupled to an induction motor of 2,200 volts pressure. Each of the exciters is sufficient for the complete excitation, the belt-driven generator being normally used for this purpose, the motor-generator acting as reserve. When the station is started, the excitation is taken from a small storage battery of 37 ampere hours capacity, which is sufficient for the excitement of one of the alternators.

Power is transmitted from this station at a tension of 33,000 volts to the town of Skelleftea, 27 miles distant, and the pulp mills at Ohrviken and Yttersfors, respectively 42 and 50 miles distant. For this purpose six single-phase transformers, each of 600 KW. capacity, star-connected in two parallel sets, are installed. The charge for power, measured at the secondary transformer stations at Ohrviken and Yttersfors, is £3 6s. per horse-power yearly. For motors within the limits of Skelleftea, however, the following tariffs have been framed: 1s. 2d. for KW. hour, or a yearly paymen per horsepower of £6 for mo-



INTERIOR VIEW OF THE GRANINGE POWER STATION

GRANINGE POWER STATION, SHOWING PIPE LINES



INTERIOR OF GRANINGE POWER HOUSE, SHOWING GENERATORS

GRANINGE POWER STATION, SHOWING TAIL RACE

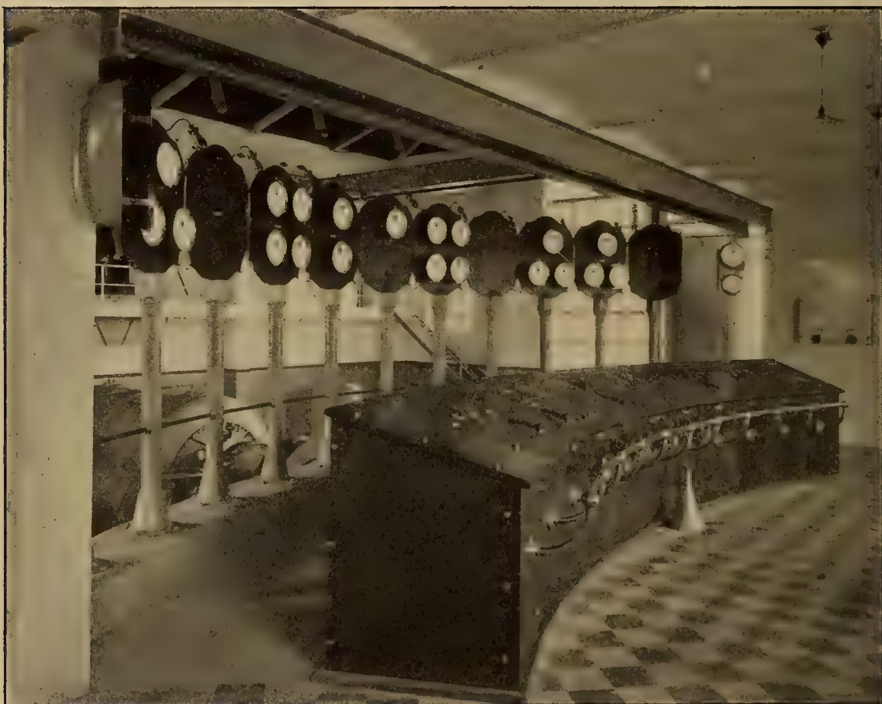
INTERIOR GRANINGE POWER STATION, SHOWING GOVERNORS

tors under 5 horse-power; £5 10s. for motors from 6 to 10 horse-power; £5 for motors from 11 to 25 horse-power; £4 8s. for motors from 26 to 50 horse-power.

It is probable that electrical energy in its various forms and applications enters more closely into the general and industrial life of Stockholm than is the case in any other city in the world. The history of the electricity undertaking of the municipality of the Swedish capital is, consequently, one of continuous progress and periodical extensions. It dates from 1890, when the authorities decided to erect, at an estimated cost of £90,000, an electric lighting station in the business centre of the city.

This station was completed in the fall of 1892, the generating machinery being two continuous-current dynamos, each driven by a vertical reciprocating steam-engine of 250 horse-power normal and 320 horse-power maximum output. There was also installed a storage battery of 2,500 ampere hours capacity, and the current was distributed at a tension of 2 x 110 volts by underground mains aggregating 34½ miles in length.

The power consumption, although small at first, rapidly grew, approximately doubled every second year, and soon called for considerable extensions. Thus in 1895 a third steam-driven generator of 500 horse-power was erected, and in 1895 two more sets of 500 horse-power each were added to the plant. In 1901 the capacity of the storage battery was doubled, and the limit of extension reached.



SWITCHBOARD GALLERY IN THE GRANINGE POWER STATION

Long ere this, however, it had been recognized that, consequent upon the rapidly increasing demand for motor and lighting services and the proposed electrification of the tramways, a larger power-station must be

erected, with facilities for future extensions and easier supply of coal and water. For this purpose the municipality acquired 23¼ acres at Värtan harbour, about two miles from the centre of the city, and in June, 1900, accepted plans, involving an estimated expenditure of £450,000, for the erection of a central station on this site and of a suitable number of sub-stations within the supply area. The first delivery of current under this scheme was made in September, 1903.

The present buildings at Värtan cover 41,000 square feet. The engine-room was built for four units of 1,500 KW., two of which were erected in the first installation. A third steam-driven generator was added during the following year, and in 1907 two turbo generators, each of 1,500 KW. capacity, were installed in the space originally reserved for the fourth unit. The boilers are of Babcock and Wilcox type, fitted with superheaters, and the steam is delivered at a pressure of 13 atmospheres and a super heat of 50-60°C. The coal, second quality Newcastle smalls, is automatically conveyed from the storage to the bunkers above the boilerhouse and thence to the hoppers of the stokers. The actual mean consumption, measured over several years, is 2.9 pounds per generated KW.

The three reciprocating engines, 100 revolutions per minute, are of vertical triple-expansion type. Barometric water-jet condensers are used, their installation having been favoured owing to the fact that the level of the engine-room is about 37 feet above the surface of the cooling water. The steam-turbines are of the Rateau horizontal type and run at a speed of 1,500 r.p.m.

THE FINNFORSEN POWER STATION ON THE SKELLEFTE RIVER

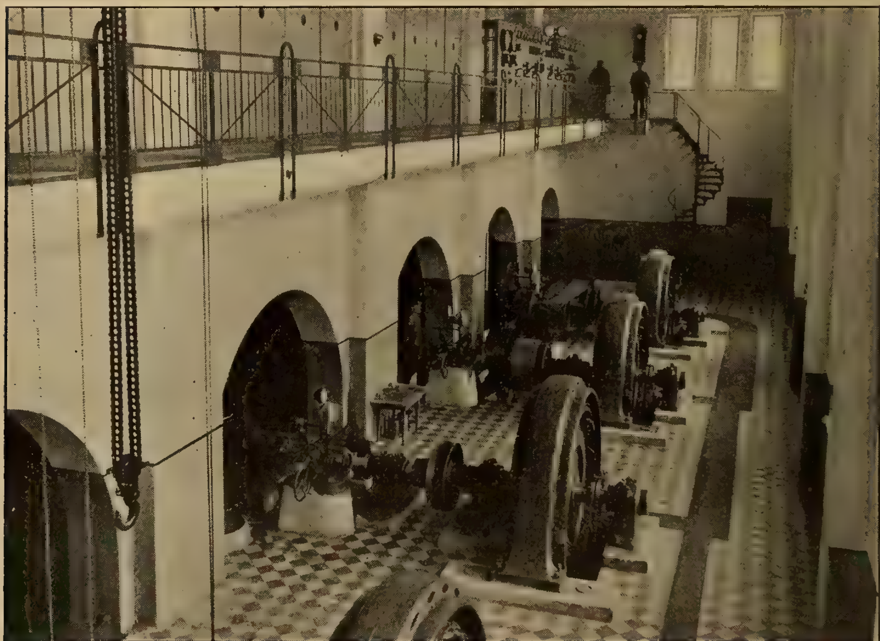
The steam-driven generators are of the flywheel type, and as also are the turbo-generators three-phase, star-connected, and wound for 6,000 to 6,500 volts and 25 periods. Each unit has a direct-connected exciter, field regulation being effected by regulating the magnetizing current of the exciter and the use of a rheostat of comparatively small dimensions, easily operated by hand.

Power is transmitted by underground cables to five sub-stations in different districts of the city. In this number is included the old steam-central, now reinforced by the

installation of two motor-generators, with an aggregate capacity of 1,000 KW. In the sub-stations the 6,000 volts three-phase current is converted into direct current of 2 x 220 volts by means of induction motor-generators. The voltage on the direct-current side can by shunt regulation be raised to about 600 volts for the purpose of battery charging, and thus it is possible to use the same type of generator for both traction and lighting services. This fact and the convenience of starting without the necessity of synchronizing and the easy parallel working with the batteries were the principal reasons for adopting induction motor generators in preference to converters or other synchronous machinery. In order to avoid sliprings, the starting resistances of the induction motors are contained in the rotors.

At the sub-stations all high-tension apparatus as well as direct-current bus bars and out-going cables are contained in the basement of the generator room. The wiring in the high-tension department is made on the cellular system, the different phases being enclosed and separated by fire-proof barriers. The oil switches are remote-controlled from instrument pillars on the generator floor; and on the direct-current side all live parts of switches, voltage regulators, etc., are located behind the switchboard, only the operating handles projecting through the panel.

During the four years following the opening of the Värtan station, Stockholm's consumption of electric power increased from about 2,900,000 to over 13,300,000 K.W hours. The total length of underground-alternating and direct-current cables in 1907 was 309 miles; the number of meters installed was about 11,000; and consumer's lamps, motors, etc., not including 7,000 KW. for the tramway motors, aggregated a capacity of 22,000 KW., as against 8,000 KW. in 1903. Recognition of the importance of these facts led to the inauguration three years ago of considerable extensions, among which



INTERIOR OF THE FINNFORSEN POWER STATION, 900-KW. ALTERNATORS. INSTALLED BY THE LUTH & ROSENS ELECTRICAL CO.

FINNFORSEN POWER STATION. 600-KW. OIL TRANSFORMERS. THE LUTH & ROSENS ELECTRICAL CO.

may be mentioned the lengthening of the engine room and boiler house to accommodate two new steam turbo-generators of 6,000 KW. each, with the necessary boilers and auxiliary plant, and the erection of a new switch house, from which the electric energy of the entire station is to be distributed to the various sub-stations.

More important, however, was the resolve to proceed with a development already oft-discussed. Public opinion had for several years designated as the future source of Stockholm's supply of electric energy the State waterfalls at Elfkarleö, near the mouth of the river Dal, but, after considerable preparatory investigation, the city authorities have recently acquired the falls at Söderfors, a few miles further inland, which gave a head of about 50 feet. Here it is proposed to erect a power-station with seven units each of 5,000 horse-power, and to thence transmit the energy by a 60,000-volt line to the capital, a distance of about 75 miles. At Värtan, which will in all probability be retained as a reserve or auxiliary station, the current will be transformed to low pressure for feeding the sub-stations. It is expected that work at Söderfors, so far at least as the hydraulic arrangements are concerned, will be commenced during the current year.

THE AMERICAN IRON AND STEEL INDUSTRY

FROM A BRITISH POINT OF VIEW

By T. Good

IN view of Mr. Carnegie's recent declaration about cheap cost of production in the United States steel industry and its importance from an international competitive standpoint, no apology need be offered for presenting a brief review of the progress, position and prospects of the American iron and steel trade from a purely British point of view. Next to agriculture, the iron group of trades constitute the world's chief productive industry, and, seeing that the United States is the world's first iron country in point of production, while Britain is foremost in point of exportation, it may prove both interesting and useful to draw a parallel from such materials as are available between the relative powers and possibilities of Britain and America as iron and steel countries. Indeed, the present state no less than the past record of the United States iron industry affords abundant material for interesting speculation. The annals of industrialism contain no more striking chapter than the record of this huge trade.

That the progress of the American iron trade down to 1907 has been great we all recognize, but it is questionable whether many of us are cognizant of the difficulties under which that progress was effected. We are not alluding to the early difficulties of 1622, for example, when the first American iron works were demolished and the workers put to death by Indians; or of twenty years later, when the second colony of ironworkers was tormented out of existence by religious fanatics; or of the next hundred years, when those who ventured to make iron in that country had to be ever ready to defend their furnaces and lives with arms; or of the eighteenth century attempts to suppress the industry by British Acts of Parliament. That story has been well told by Mr. H. N. Casson in his "Romance of Steel" (E. G. Richards, London; A. S. Barnes & Co., New York).

We are concerned now with the modern difficulties, those difficulties which hamper the American iron and steel trade in competition with ourselves and which even such an authority as Andrew Carnegie seems to forget.

In recent years, we Britishers have been so consistently fed on a diet of glowing accounts of the natural resources and human skill of America that we have failed to take due note of the obstacles that country has had to overcome in her rapid industrial development and commercial expansion. We have been led to picture in our mind's eye a nation of superlative intelligence, marvelous enterprise, and prodigious energy, possessing inexhaustible supplies of coal and iron ore, the cheapest of transit, and the latest and best mechanical appliances. But, as a matter of fact, our great contemporaries enjoy no monopoly in good things. Their principal iron ore deposits are about 1,000 miles distant from their coalfields, and their manufacturing plants are mostly 400 to 500 miles from seaboard—a big disadvantage in the matter of competition in foreign markets with a country like Britain, where ore, coal, furnaces and harbours are all practically side by side.

Then again, while America as a "new" country has enjoyed the latest mechanical contrivances, her industries have been hardened by rash and inexperienced finance, with all its resultant fits and starts and panics. Moreover, if coal and ore have been cheaper in the States than here, labour has been twice as costly; while, so far as transit is concerned, if our rivals have enjoyed low ton-mile rates, they have had to stand the cost of very long haulage distances. The net result is that the prime cost of iron and steel—the cost of assemblage and production—despite superior appliances, has been, and is to-day, higher in the United States than in this country, Mr. Carnegie's declarations notwithstanding, as we shall see presently. In the light of these circumstances, America's progress in iron, especially her progress in exploration, is all the more remarkable than bald statistics would indicate, remarkable as these are:

PRODUCTION OF PIG-IRON IN THE UNITED STATES

	Tons
1865	831,000
1870	1,665,000
1875	2,023,000
1880	3,835,000
1885	4,045,000
1890	9,202,000
1985	9,446,000
1900	15,778,000
1905	22,992,000
1907	25,781,000
1908	15,936,000

How the United States has progressed relatively to the world's demand and comparatively to Britain and Germany may be seen by a glance at these figures:

PRODUCTION OF PIG-IRON IN MILLIONS OF TONS—AVERAGES

	The World	Gt. Britain	Germany	U. S.
1880-4	20	8	3	4
1885-9	25	7	4	6
1890-4	28	7	5	7
1895-9	36	8	6	11
1900-4	43	8	9	16
1905-8	55	9	11	22

In the last ten years the United States has provided 180,000,000 tons of pig-iron, against 90,000,000 tons in Great Britain. As the population of the United States is more than twice as large as that of Great Britain, it will be seen that our American rivals have not yet beaten us in point of *per capita* output, spread over a period of years.

The United States, however, with its big home demand for railroad and other material, has a much larger *per capita* consumption of iron than this country has. Our rivals export little more than one-twentieth of the products of their iron and steel works, while we are obliged to find markets abroad for practically half of our output.

IRON AND STEEL EXPORTS FROM

	United States, Tons	Great Britain, Tons
1906	1,325,000	4,682,000
1907	1,302,000	5,311,000
1908	964,000	4,233,000

It must be explained that more than a third of our iron and steel exports take the form of pig-iron, whereas only one-sixteenth of America's exports consists of pig-iron. It follows, therefore, that our iron and steel exports are of somewhat less value, per ton, than those of our rivals. On the other hand, if we include machinery, our iron and steel exports reached a value of £106,000,000 in 1907, against a total of £39,000,000 worth of iron, steel and machinery exported by the United States, while, if we took also ships into account, British trade supremacy would be still more marked. All the same, American competition has increased and been disturbing. Twenty-two years ago, the United States exported £3,000,000 worth of iron and steel; twelve years ago, £11,000,000 worth; in 1907, £39,000,000 worth. The growth of rivalry revealed in these figures, coupled with the fact that the Americans are still adding to their productive capacity, provokes speculation.

What, then, are the real competitive powers of the United States? It is worth noting that even in that vast country the cry of the pessimist is being raised at last. We are told that both the Lake Superior iron ore deposits and the Appalachian coking-coal measures are

showing signs of exhaustion. Conferences are being held to discuss the approaching end of American mineral resources! This is in strange contrast with the graphic pictures of that country's fabulous supplies of coal and iron, which have been so frequently drawn. Let us at once state that, in our opinion, there is no more cause for alarm concerning America's resources than there is ground for fear that American competition will overwhelm British trade. Both countries can, and will, prosper.

With regard to coal, it has been contended that outside the Appalachian basin, which extends from Pennsylvania to Alabama, there is practically no coal suitable for making furnace coke. On this assumption and the further hypothesis that the recent rate of increase of coal consumption will be maintained, gloomy predictions have been based. Well, we know something about coal famine predictions in this country, and how groundless they are. If groundless in our case, then how lacking in foundation they must be when applied to the United States! The coal now in sight in the Appalachian basin—coal from which the cheapest coke in the world is made—will, on a conservative estimate, last 100 years at the present rate of output; while, making all reasonable allowance for increasing rate, this field will not be exhausted before the middle of the century. There is more than a possibility that the recent rate of increasing coal consumption will not be maintained. For one thing, water power will be more largely utilized in the future. Besides, vast deposits of coal—in some cases, excellent coking coal—have recently been located in other parts of the North American Continent. At several points on or near the Pacific coast coal has been found, notably in California, apart from the well-known deposits in British Columbia. There seems good reason for assuming that there is quite as much coal in the West as in the East, and that the day may come when the West will rival the East as a manufacturing district, for much iron ore, as well as coal, is known to be deposited there. While it is well that a note of warning should be uttered, and a protest raised against the wasteful methods of mining in the United States, enormous quantities of coal being irretrievably lost in the mad scramble to show a big output, it is really absurd to talk of the early end of that country's natural resources.

The foundations of the American iron and steel industry, both in coal and ore, are sound. Despite the enormous quantity of ore consumed, the visible supply seems to increase! Fresh deposits are being constantly met with. There is actually as much ore in sight in the Lake Superior district to-day as there was estimated thirty years ago. Competent authorities calculate that there is still a reserve in that locality of something like 2,500,000,000 tons, and this ore yields well. Much has been said about the deterioration of Lake ore, but the deterioration has not been very great. In the last ten years (up to 1907) the quantity needed to produce a ton of pig-iron has only increased from 1.68 to 1.88 tons. It has recently been estimated that in what are known as the Southern States of the Union, there is quite as much ore in sight as there is in the Lake district, making a total of not less than 5,000 million tons of good workable ore available in those two districts. The most conservative authorities have put the total at not less than 3,840 millions of tons. Southern ores are leaner than those of the North, and are high in phosphorus, but they are very serviceable, and with improvements in treating may become still more valuable. Besides, there are other reserves in sight. Near the Atlantic coast, in New Jersey, there are ores suitable for some kinds of high-class steel, while in the extreme West, in California and other parts, enor-

mous deposits of good ore have recently been found.

In addition to those vast reserves of ore—estimated by at least one authority, at 10,000 million tons—within the United States there are positively enormous deposits of easily mined ore in Cuba, which may be imported into the States and, with coal or coke brought down to tidewater, a big industry might be built up on the Atlantic seaboard. In Cuba, it is estimated there are about 2,000,000,000 tons of ore available, and most of the "claims" are in American hands. As an indication of what may happen in the future, it may be mentioned that already one big steel company, holding a large number of Cuban ore "Claims," has a plant at tidewater.

With such vast iron and steel-making resources as these, to say nothing of the more than probable future discoveries of additional mineral deposits, and with an abnormally rapid increase of population, and all that that implies in growing demands for steel, who can doubt that the United States iron industry has a great future in store?

But the chief point of interest for us in this country is the question of exports. Will our American rivals, in addition to satisfying the big and progressive demand which must again assert itself within the Union, have either the power or inclination to seriously challenge our supremacy as an iron and steel-exporting country? Will our big competitors carry into effect their oft-repeated threat to annex the world's trade in iron products? Mr. Carnegie declares in his evidence before the Ways and Means Committee, charged with inquiry into the incidence of the United States tariff, and in a notable magazine article, that the cheapest steel in the world is already produced in the United States, and that Great Britain has reached the apex of her manufacturing powers, and is in a very bad way in the matter of raw materials supplies. According to Mr. Carnegie, the American steelmaker is not only the most up-to-date manufacturer in the world, but enjoys the best, cheapest, and most abundant supplies of coal and iron and can, if he chooses, easily beat all his competitors, especially played-out Britishers. To question such an authority may seem presumptuous, but, as Mr. Carnegie gives no figures and few facts in support of his contention, we may be pardoned for doubting its accuracy. Besides, we have heard this story of America's superlative powers so many times during the last ten or fifteen years, and still find United States steel occupying a third rate position in the world's markets (outside the Union) that we are getting quite skeptical. As an iron and steel exporting country, America is still leagues behind both Britain and Germany. These two countries have in the last fifteen months (October, 1907, to December, 1908) exported about 9,000,000 tons of iron and steel, while practically half the wonderful furnaces and mills in the United States have stood idle! If Mr. Carnegie's theory is correct, how comes it that well-nigh a billion dollars' worth of American plant has been idle since October, 1907, while British and German manufacturers have divided between them nearly nine-tenths of the world's available trade? Why is this so, if, as Mr. Carnegie asserts, the United States can manufacture more cheaply than this or any other country? Mr. Carnegie's theory does not seem to square with the facts very well.

As this question of cost of production is so very important just now, let us try to get down to the bed-rock facts. The cardinal point in the problem of international competition in steel and steel goods is the price of pig-iron. The second point is cost of manufacture. The third is cost of transit. Pig-iron is the foundation of the whole business. That country, with the cheapest pig-iron available, need fear no rival in

steel. Now, what is the plain, unvarnished truth about pig-iron? To get at the exact average cost of production in either country is, perhaps, impossible, but we have ample facts and figures available to enable us to get near enough the mark of accuracy for all practical purposes. First, let us take a glance backward. Let us point out that if one-half of what we heard ten or twelve years ago about American proficiency and superiority has been true, British iron and steel goods would have been swept clean off the world's markets before now! We were told then, as Mr. Carnegie tells us now, that the United States could make all kinds of iron and steel cheaper, better and quicker than we could, and that our days as an industrial and commercial nation were numbered. That was the theory ten and twelve years ago. What is the fact to-day? In the last seven years, for every dollar's worth of American iron and steel that has been sold abroad, we Britishers have disposed of a sovereign's worth!

It was ascertained by the United States Industrial Commission that the average cost of producing a ton of pig-iron in that country in 1894 was 34s. 6d. Leading American ironmasters did not hesitate to predict that they would soon be able to produce iron at 30s. a ton, and American steelmakers announced their intention of capturing the world's trade. Two eminent authorities, Messrs. Jeremiah and A. V. Head, after exhaustive inquiries and elaborate calculations, gave us in 1899 in the *Proceedings of the Institution of Civil Engineers* the following figures as the average prime costs of a ton of steel-making pig-iron, Bessemer or hematite in Britain and America:

COST OF PIG-IRON PER TON AT PITTSBURG

1.66 tons of ore, at 12s. 8d.	£1	1	1
16 cwt. of coke, at 7s.		5	7
12 cwt. limestone, at 3s.		1	9½
Labour		2	0
Repairs		1	0
Other items		1	0
	£1	12	5½

COST OF PIG-IRON PER TON AT MIDDBROUGH

1.95 tons of ore, at 15s. 2d.	£1	9	7
20.5 cwt. of coke, at 15s. 6d.		15	10½
9 cwt. limestone, at 3s. 9d.		1	8½
Labour		3	0
Repairs		1	0
Other items		1	0
	£2	12	2

With pig-iron costs so much less in America than here, our rivals could make, it was asserted on high authority, steel rails at 50s. a ton, against ours at 79s., and all other products at relatively low prices. Clearly, we could not hope to compete with the United States. Our industrial downfall was loudly heralded. Some of us took fright. We were assured that there was nothing left for us but to become an American colony. Leading American ironmasters, steelmakers, and engineers declared that their plants and appliances were absolutely the "finest on this planet," and that they were about to "lick creation." Mr. Carnegie and his friends, some leading Englishmen among them, dinned the American superiority doctrine in our ears morning, noon and night.

Well, we know what has happened since then. In this country costs of production have been reduced; in America they have been very substantially increased. British industry has taken a new lease of life; our rivals, so far as international competition is concerned, have lost ground. If we did not succumb to American competition ten years ago, we are not likely to do so now. Instead of American pig-iron costs remaining at 32s. 5½d. a ton, or falling to the boasted 30s. level, the United States Industrial Commission found the average standing at 61s. 6d. a ton in 1900. In 1896-97 Bessemer pig-iron was delivered in Pittsburg works at 40s. a ton. To-day it is quoted at 72s. 6d. In 1898 the Industrial Commission estimated the cost of production at 39s. a ton. In 1908 the Bureau of Corporations shows the Tariff Committee that the cost is 58s. 4½d. per ton. In the last twelve months the average price of English East Coast hematite has

been 57s. 6d. a ton. Thus we find that after all these years of boasting about the United States cheap production the "price" of our iron is 10½*d.* per ton *less* than the prime "cost" of American iron. Steel-making pig is being delivered at Sheffield's works to-day (the beginning of 1909) 8s. 6d. a ton cheaper than at Pittsburg works, and the chairman of the great United States Steel Corporation declares that pig-iron is being produced in England 15s. 2½d. per ton cheaper than it can be made in his country! And Mr. Gary is not so far wrong as some people imagine. This is evidenced by the fact that, although United States iron producers received more than 20s. a ton more for their pig than British producers got for theirs in the two years 1906-07, yet some of them were soon in financial difficulties when depression overtook them. It comes to this, then, that, according to the best evidence available, whereas ten years ago our American rivals were producing steel-making pig iron 19s. 8½d. per ton cheaper than we were, there is now a balance of 15s. 2½d. per ton in our favor. In face of such figures as these it is difficult to find much justification for Mr. Carnegie's theory to-day, however much there may have been for it at one time.

Mr. Carnegie seems to forget that since he was actively engaged in business, costs of production have very largely increased in the American iron and steel industry, while in this country, as a result of vastly improved methods, production costs have actually come down, despite higher prices for some raw materials. It is not exaggeration to say that within the last ten years our manufacturing processes have been well-nigh revolutionized for the better, that our visible supplies of raw material—iron ore, at any rate—have increased, and that our competitive powers have been well developed, while the relative position of our American rivals has been weakened in foreign markets. In the United States, production costs under practically every heading have gone up—mining, assemblage, and smelting costs are all vastly higher than they were ten years ago. Whereas Lake Superior iron ore was then mined at 1s. 8d. per ton—7½d. a ton royalty or purchase in the ground, and 1s. 0½d. for labour—the royalty is now between 3s. 6½d. and 4s. 2d. per ton, and the labour cost, due to deeper and more difficult mining, is 2s. 1d. per ton. Then, again, to get this ore from the mines to the smelter—two journeys by rail and one by boat—now costs about 10s. 6d. per ton, against 8s. 4d. ten years back. Moreover, the average yield of iron per ton of ore has declined by nearly one-fifth in case of the principal ranges. The net result is that a ton of Pennsylvania pig-iron, in ore alone, must cost at least 14s. more than it did in 1899. Some authorities argue that the difference is greater. The cost of labour per ton has declined a little, but the cost of fuel and limestone has gone up, besides which larger quantities are now needed per ton of iron produced. Mr. Schwab gives these figures:

COST OF A TON OF PIG-IRON IN PENNSYLVANIA

	1899	1908
Ore	$4.50 to $5.00	$8.50
Limestone	.35	.75
Coke	1.75	2.62
Labour and conversion	1.65	1.30

According to this calculation, whereas the cost of a ton of American pig-iron was somewhere between 34s. 4½d. and 36s. 5½d. in 1899, it is now 54s. 10½d. These are Steel Trust figures. Taking the figures of the Industrial Commission for 1899, and those of the Bureau of Corporations for 1908, both of which sets cover the costs of practically the whole country, and are not confined to those of the big Trusts which claim to produce more economically, we have a rise from 41s. per ton to 58s. 4½d.

In 1896-97-98-99, both the cost and the price of pig-iron were, no doubt, less in America than here; to-day, both advantages are held by this country. Incidentally, it may be noted that in drawing a comparison between the United States and Great Britain, we have to consider not merely the difference between actual prime costs of production, but must also make allowance for *profitable* costs, or prices, in relation to capitalization. Capital charges per ton of output are something like three times as high in America as in this country. This circumstance renders the American position, competitively, actually worse than the figures just quoted indicate. In the eight-year period, 1900-07, covering a boom and a depression, the prices of pig-iron were higher, on the average, by 17s. per ton in America than here. That "price" is not "cost," we admit; but there is no evidence to prove that the American smelter, with his high price, has made any greater profit per ton than the British smelter with his much lower price. Indeed, no less an authority than Mr. G. Stephen Jeans, in his *Iron Trade of Great Britain* (Methuen, London), says that profits on iron and steel production are "somewhat less" in the United States than here.

With such a substantial rise in the price of American pig-iron, it is only natural that the prices of steel products have gone up, and then, as we contend, our United States rivals are not in nearly such a good position to challenge our supremacy in exportation as they were a decade ago. Taking the price of certain finished steel products in 1897-98, and comparing them with those of 1908, another period of depression, the *Iron and Coal Trades Review* index shows an advance from 104s. 2d. per ton to 162s. 5½d. If our rivals failed to annex the world's trade in iron and steel in the "nineties," there does not seem to be much likelihood of their accomplishing such a task at the present time.

But Mr. Carnegie still asserts that the cost of steel production is less in America than elsewhere. No wonder that, when pressed on the point, he declined to produced figures! Mr. Carnegie merely pointed to the huge "Earnings" of the Steel Trust as justification for his theory, forgetting that there is such a science, or art, as "expert accountancy." It would be interesting to know what Mr. Carnegie means by "steel," and what he means by "costs of production." There is steel and steel; and there are profitable and unprofitable costs of production. If comparison is drawn between the prime costs of a ton of American rails rolled from "piped" ingots insufficiently cropped—rails of which one in about every four is defective—and British rails rolled from the solid only, then we may be induced to accept Mr. Carnegie's opinion; but taking, as we are entitled to take, quality for quality, we beg to challenge it.

With a big home market well protected the American steel trade will flourish, no doubt; but the day is in the dim and far distant future when our rivals will be able to beat us in the world's markets. The enormous distances which separate the iron ore deposits from the coalfields, and the manufacturing plants from seaboard, in the United States, coupled with positively extravagant capital charges, must always severely handicap that country in competition with Britain.

So far as it is possible to forecast the future, it may be anticipated that costs in America will continue to move upward rather than downward. Fuel is almost sure to increase in price. Not only is there likely to be a gradual rise in the cost of coal-getting through natural conditions, but the appalling and wanton waste of life in American mining must lead, at an early date, to the imposition of legislative restrictions similar to those in force in this more humane country, restrictions which

will add largely to the price of coal. Then, as regards ore, it is not likely that this will ever be so cheap in America in the future as it has been in the past. Royalties are increasing year by year, and the cost of getting the ore is going up. And it is more than probable that transit rates will increase.

No; American competition need not frighten us, Mr. Carnegie's tall talk need not disturb us. In cheap, abundant and convenient supplies of raw material, in geographical situation, in sound capitalization, and in skilful labour, we hold a combination of advantages enjoyed by no other country—not even by the vast United States. No country can produce cheaper and no country can produce better iron and steel than we can, and it is high time we realized our advantages, abilities and capabilities. If American statesmen and business men lay their plans in the belief that Britain is a played-out nation, they will make a huge blunder.

Current Topics

IT has been said that everything is relative, and there is doubtless much truth in the saying. The difficulty lies in the determination of a basis for comparison, and sometimes this basis is supplied in a manner which makes everyone sit up and take notice. Mr. Hurd's article in the present issue shows the extent to which the appearance of the *Dreadnought* practically rendered the battleships of every other naval power obsolete, and caused the present rush of the leading nations to bring their navies up to date by the construction of vessels which should meet the new standard thus set up. In the light of present experience, it may be questioned whether it was altogether wise to create a standard which involved such a transformation of existing naval equipment; but it is better to lead than to follow, and when we remember the revelation which the contest between the *Monitor* and the *Merrimac* effected as regards the navies of that day, we may well understand the importance of ample preparation at the present time among the great naval powers.

Much has been said about the enormous cost of modern battleships, but it must be remembered that the expenditure in this respect is small in comparison with the equipment and maintenance of land forces. In the war between Russia and Japan the cost, both in men and in money, of the battles about Mukden and Port Arthur was enormous compared with that involved in the single naval contest at Tsushima; and yet it was the latter which decided the event and compelled the peace of Portsmouth.

To any country which possesses a seacoast a powerful navy is an absolute essential, not as a menace, but as a preserver of peace; and until the navigation of the air succeeds that of the seas it will be the element of sea power which will decide the action of governments for war or for peace, acting as the most effective police power at present available.

COMMENTING on Mr. Booth's articles on Cotton Spinning which have appeared in our recent issues, a Lancashire paper draws attention to what it terms the bigotry and fanatical frenzy with which the Lancashire people attacked the early machinists and their ma-

chinery. Arkwright and Hargreaves both suffered for their inventive genius. But we do not know that Samuel Crompton, the inventor of the mule, suffered much from the people generally, beyond an insatiable curiosity as to how he contrived to spin the very excellent weft which he sent out from Hall-i'-the-Wood, and for which he got such excellent prices. Samuel Crompton was worried out of his life, and finally, unable to afford the expense of a patent, divulged his secret to the Manchester manufacturers in return for their promise to pay him well for it. Of course, they never did pay him. They robbed him of his invention. Ultimately he was awarded a small sum by the government in recognition of what he had done for the country. So it would appear that it was not alone the working men who were to blame. Machinery does undoubtedly often work injury to individuals in its initial development. Machinery which will cut cheap nails pushes out the maker of hand nails. In the long run it may be there is more employment possible, but there are still those among us who are not yet persuaded that the human family is any better off for its modern copious manufacture by machinery. Can it be we are passing through a mechanical age that will expire when Mr. Carnegie's prophecies come true, or that the future of Professor Arnold, with less arduous metallurgy by electricity, will be the next age?

AT the joint meeting of engineering societies in New York held recently to discuss the subject of the conservation of national resources, the question received, almost for the first time since it has been conspicuously before the public, something like a scientific and rational consideration. It was made clear at that time that the engineering profession has for a long time been actively engaged in doing just what the general public has begun to think ought to be done, and that a very large part of the work of the engineer has been expended in efforts to reduce waste and promote the most efficient use of natural resources.

In the department of metallurgy the introduction of the hot-blast stove and the development of the Bessemer process are estimated together to represent a saving of nearly one hundred million tons of coal every year above the amount which would be required if the older methods were still employed. The introduction of the large gas engine for the utilization of the waste gases for the production of power is already beginning to have a bearing upon the further reduction in fuel consumption in iron manufacture, while the widespread use of small sizes of coal, due in large measure to the scientific work of the late Eckley B. Coxe, has, in the past twenty years, greatly extended the quantity of available fuel from the anthracite coal regions of Pennsylvania and other districts.

The subject of the utilization of water-power brought out in the discussion the fact that there has been little or no variation of the flow of streams for the last 100 years, so far as the records of gaugings show. Of the 25,000,000 horse-power now developed in the United States, about one-fifth is derived from water and four-fifths from the combustion of coal. While it has been estimated that there is sufficient hydraulic energy available to replace all the power now obtained from coal in the United States, the figures are not by any means authoritative, and it is most desirable that a government survey be made of this national source of energy.

The entire purport of the discussion was to the effect that reduction of waste was still possible and desirable, but that it could best be effected along the lines which the engineer has been developing for a generation.

WILLIAM HEWITT

A BIOGRAPHICAL SKETCH

WILLIAM HEWITT, whose portrait we publish this month, has been identified with the iron and steel industry of the United States all his life. Born in 1853, at Trenton, N. J., of English ancestry, he received his education at the New Jersey State Model School, at the Lehigh University, where he won a scholarship, and at the Stevens Institute of Technology, in which latter institution he was a member of the first class. During his student period at Stevens he accompanied the late Dr. R. H. Thurston, then professor of mechanical engineering at the Institute, on his trip to Europe in connection with the latter's work as Commissioner to the Vienna Exposition of 1873.

In 1874 Mr. Hewitt entered the service of the Trenton Iron Company, where he served as paymaster, then draughtsman and later as assistant to the president and general manager, engaged in remodeling the works and installing new machinery in the works. In 1879 he was elected vice-president of the company, a position which he held for twenty-four years, being employed since then in an engineering capacity.

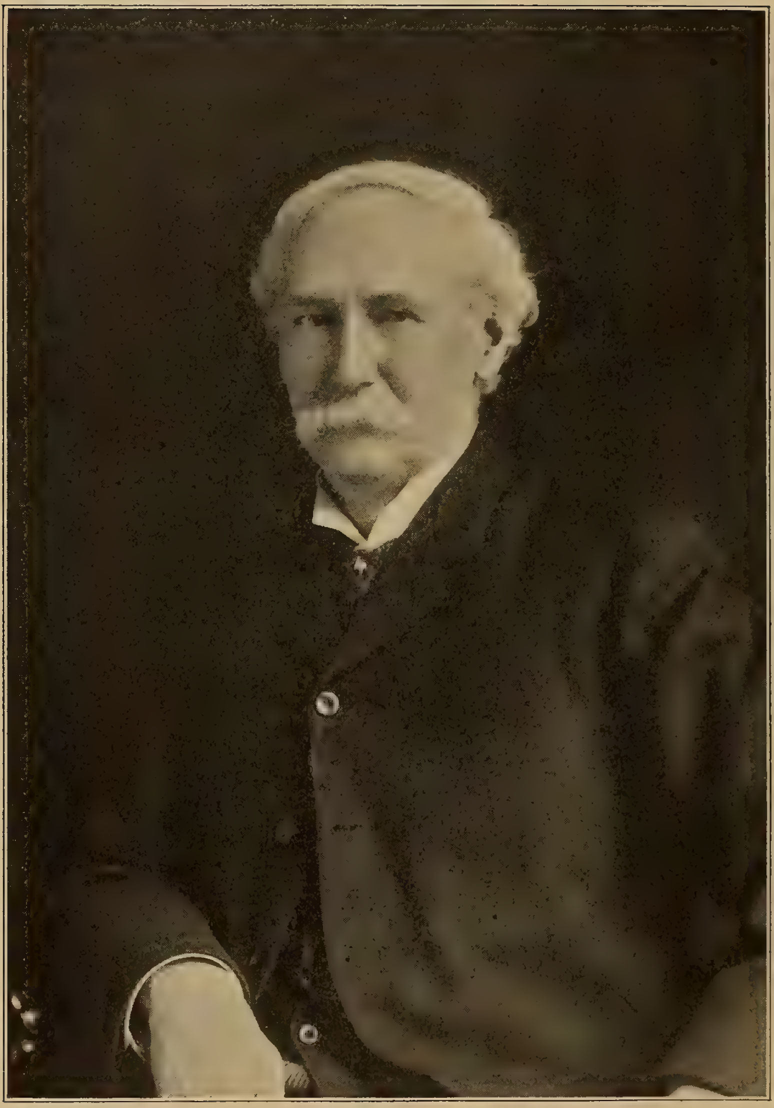
When the company engaged in the manufacture of wire rope in 1885, Mr. Hewitt devised, patented and installed machinery for the purpose, whereby the wires are laid into strands and the strands into rope simultaneously, performing in one operation what in usual practice requires two. These machines have been in continuous and successful operation ever since. Mr. Hewitt has also developed and patented numerous other inventions. In connection with the manufacturing side of the subject Mr. Hewitt has also conducted important investigations upon the applications of wire rope, and more especially the effect of bending upon wire ropes, the results of these investigations being first embodied in a paper read before the Engineering Association of the South, and since then in a book on "Wire Rope," published by the Trenton Iron Company. The result of this study of wire rope was the development of an original formula for the determination of bending stresses, taking into account the spiral lay of the wires, and also a formula for determining the curvature for given angles and stresses.

Mr. Hewitt has been concerned in the laying out of many aerial tramways, haulage plants and power transmissions, and is the author of various publications issued by the Tren- Iron Company on these and allied subjects.

Mr. Hewitt has contributed numerous articles to the technical journals, including "Cableways for Unloading Vessels," "Across the Chilkoot Pass by Wire Cable," and "Progress in Aerial Transportation," in the pages of this magazine, as well as papers before professional societies.

He was first president of the Alumni Association of Stevens Institute, to which office he was re-elected in 1894. He was one of the original founders of the American Society of Mechanical Engineers, a member of its council (manager) from 1884 to 1887, and is also a member of the Engineering Association of the South.

It is interesting to note that Mr. Hewitt's grandfather, John Hewitt, came to New York from England in 1796 as representative of Boulton & Watt, and was instrumental in the construction of the first steam engine built entirely in the United States.



CHARLES B. RICHARDS.

PROFESSOR OF MECHANICAL ENGINEERING OF YALE UNIVERSITY.

See page 192.

CASSIER'S MAGAZINE

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MODERN METHODS OF TEMPERATURE MEASUREMENT

By Joseph H. Hart, Ph.D.

SO many interesting developments are constantly occurring in the theory and practice of thermometry, and the matter is of such prime importance to the entire engineering world, that a clear and concise statement of conditions is not undesirable. The majority of developments in this work are more or less complicated from a theoretical point of view, and the literature on the subject is so loaded down with technical details and points of interest only to the physicist that it is not unusual for the average individual to consider this subject outside of his line. However, the matter is of such prime importance in almost every modern utilization of heat that the subject cannot be ignored, and the result has been an imperfect knowledge, which has hampered developments and resulted in a lot of work not only of little value, but absolutely unnecessary, in the light of a fuller knowledge. When we say that temperature and changes of temperature are almost the only manifestations of heat perceptible to the senses, and that we deduce all our ideas in regard to heat quantities from this property, and that almost every measurement in the latter is based upon the measurement of temperature, we begin to realize its importance. Thus, the coefficient of expansion of all materials is measured per unit rise in temperature. Specific heat and all heat units are defined as the heat required to raise a certain material through a certain temperature difference. Many such illustrations could be given showing the interrelation of temperature with all other heat developments and the absolute dependence of their development upon the development of the latter. Now when we say that we have no accurate method of measuring temperature and that we do not know any thoroughly reliable method of measuring it over more than a limited range, we begin to see the difficulties involved in the problem. This difficulty but increases in significance with the wider range of temperatures, steadily becoming more and more applicable in modern developments. Thus to-day we have a range in temperature extending possibly from the point of production of liquid air and even from that of liquid and solid hydrogen up to and beyond the temperature available with the electric arc or with the utilization of thermite. Dr. Goldschmidt, the inventor of the commercial processes using thermite, frankly admits that the temperatures obtained are beyond all present methods of meas-

urement. With the latter method, a temperature three or four times as high as that of the electric furnace can be produced, it is believed; but no methods of getting even approximate values of this temperature are possible.

The entire trouble is in the ultimate foundation of temperature measurements and the theory upon which this temperature measurement is based. The same trouble holds to a greater or less extent throughout the entire realm of science, but the difficulties which have arisen here have not been pronounced in other developments. Temperature in itself cannot be measured; it is a perception primarily. We can tell within a reasonable limit when one body is hotter than another, and when one body is colder than another; but these variations in perception are inexact and have a limited range. Now the same problem has arisen in the measurement of electricity, force, work, and almost any of the known physical constants, and the processes which are used in other physical developments do not hold here. The measurement of temperature is analogous to the measurement of the force or time, and no absolute units have as yet been obtained. One or more tentative developments have arisen, several of which promise greater or less possibilities. To illustrate this problem, we will take for consideration the measurement of time and force. Both of these measurements are based upon the proposition that if one quantity is always proportional to another quantity either can be used to measure the other. Thus, in the measurement of time we hypothecate a uniform motion or an equivalent motion and use the proposition that in uniform motion the distance traveled is proportional to the time taken, and thus we find a measure for it. Again, in the modern watch or any of the instruments for measuring time, we invariably measure distance and call it time. In somewhat the same way we measure force. We find that the force is proportional to the mass upon which it acts, and to the acceleration which it produces. In the majority of force measurements we keep the acceleration constant by using weight as the measuring force, whereupon the force is proportional to the mass and measured by it.

Now in temperature measurements we try to use the same process. We have certain changes in temperature which produce corresponding changes in the size of a body, known as expansion, and we use this expansion and call it proportional to the temperature, and thus to-day have developed a temperature scale based on this. Thus, in reality, measurement of temperature is simply measurement of expansion or the measurement of one of several different properties of matter which have been found to vary with the temperature and to be more suitable in regard to the practical details met with in the procedure. The difficulty lies primarily in the fact that the proportionality between the temperature and the property utilized is not constant for any one material or even approximately so, except within a narrow temperature range.

Thus, we are more or less familiar with the mercury and alcohol thermometers, considerably less familiar with the air thermometer, and practically unacquainted with some of the higher types which use other properties as proportional to the temperature. The mercury thermometer has undoubtedly served a distinct purpose. By its aid we have obtained a conception of specific heat and other heat units and a possibility of measuring with more or less accuracy. Mercury has undoubtedly proved a most suitable thermometric substance for ordinary work when practical details are concerned. However, the taking of an ordinary temperature accurately is a complicated matter. Mercury in the bulb of the thermometer, and the bulb itself, have certain specific heats when inserted

into the material for the measuring of its temperature, and a resultant transference of heat always occurs and a resultant mean temperature is invariably obtained. This can be made very small in practice, but it is always present. Again, not only does the stem of the mercury thermometer have inequalities in its cross-section, thus affecting the readings, but effects due to variable pressure and the expansion of the material of which the thermometer is composed produce invariably discordant results. Much literature has been written on the development of accurate mercury thermometers, but it is an open question whether the problem is such as to warrant this expenditure of time and labour. There is no exact relation between temperature measurement obtained on such a scale and other physical constants. Thus, a pound of water at the temperature of melting ice mixed with a pound of water at the boiling point of water does not give a temperature midway between, as measured on the present thermometric scale. This is explained now by the assumption of variable specific heat at different temperatures for the two parts of the substance undergoing mixing, but this latter is a mere makeshift to explain the discordance. Thus, specific heat and latent heat measurements extended to the third and fourth significant figure are worse than useless and very misleading in the conclusions that can be drawn from them, as these results are based upon variable fundamental units, and the corrections necessary are often as large as the quantities themselves.

Now there is no doubt that expansion of matter as proportional to temperature has reached its limit for temperature measurements. The wide range in temperature available today, not only in laboratories but in industrial projects as well, has shown the utter futility of such progress. Not only does the expansion of any material vary with the temperature, but this property as a measurable quantity ceases in most materials to be available except through a comparatively low temperature range; and other resultant developments have arisen. Many other properties of matter are now used as a basis for temperature measurements, offering more or less practicable solutions of the problem; but none of them, however, prove entirely satisfactory.

We will now consider the development of the air thermometer and what is known as the thermodynamic scale of temperature. Air was used as a thermometric substance in place of mercury on account of its much wider range of expansion and its apparently more constant proportionality to temperature. Thus it was found, in using mercury scales between melting ice and boiling water, that a gas expanded regularly 1/273 of its volume per unit rise in temperature on the mercury scale if the pressure was kept constant throughout, and that the pressure increased at approximately the same ratio for each unit rise in temperature thus measured if the volume was kept constant. From a theoretical consideration of the kinetic theory of gases in regard to heat quantities, it was assumed that this law would continue in both directions beyond the point here mentioned, and the process of extrapolation, if carried down sufficiently, will result in theoretical zero of temperature at 273 degrees below melting ice if the measurement is made on the centigrade scale. It was found that this air thermometer scale agreed much more accurately with what is known as the thermodynamic scale. The temperature units in this latter scale are based upon energy changes. Equal amounts of energy in a permanent gas from theoretical conditions produce a proportionate rise in temperature, so that the temperature reading on this scale is always proportional to the energy in the material. This latter condition seems to be true in the case of gases between the points where they cease to be

vapours and become permanent gases and the dissociation temperature of the gas. At least, as far as theory and practice have yet gone in verification of these conditions, the air thermometer is distinctly a step in advance. Thermometer changes are undoubtedly due to the changes in energy of the molecules, and the attempt to connect this directly with the temperature in this development in the production of a satisfactory system of measurement is a step in the right direction.

However, the utilization of air as a thermometric substance is very objectionable in practice, and has limitations at both ends of the temperature range. The practical details are more important at the upper end of the measurement, for the air must be confined in a vessel for the measurement of its volume or pressure, and temperature changes affect these working conditions and limit the accuracy of the results. Thus, the coefficient of expansion of almost any material is practically unknown, owing to the rate of change of this with high temperatures. It is based upon temperature measurements, and we can only use methods for approximating these values. This condition has extended in both directions from ordinary temperatures, and is present even in the measurement of these. In addition, at the lower temperatures the gases tend to become vapours as they approach more closely their liquefying points. Thus a measurement of temperature is a problem analogous to that in which a man tries to lift himself by pulling on his own boot straps.

The problem is met in a more or less exact manner by employing several methods of attack and taking as satisfactory results which are in accord with all the various methods. Thus, the electrical resistance of various materials is ordinarily measured over a common range of temperature. The coefficient of change in resistance per unit temperature change is noted, and the rate of change in this quantity with temperature range is also determined. The process of extrapolation is then employed and the reverse problem undertaken. Thermoelectric phenomena are also used in a development of temperature measurement by the same process.

There are several theoretical conditions, a consideration of which permits of further light on the temperature problem. Thus, Stefan's law that the radiation from any material varies as the fourth power of the temperature thus measured is to-day accepted as a condition approximately accurate and true from theoretical considerations. This latter has led to the development of a new system of thermometry for high temperatures, known as radiation thermometry. The temperature is measured or deduced by various methods, and undoubtedly the accuracy of any thermometer scale and the various temperatures available under any conditions will be subjected to the test of this process, and thus temperature measurement or deduction will have been reduced to a belief in the truth or falsity of Stefan's law. It must be remembered, however, that this law in its inception was defined from measurement of temperature as ordinarily understood. However, the utilization of this development for temperature measurements is based upon theoretical considerations absolutely.

Thus is shown in a more or less fragmentary manner the situation in regard to temperature measurements as it exists to-day. It also explains more or less the present condition of data relating to materials at high and low temperatures and the inadequacy of the results for ordinary applications. It can be said, in this development more than in any other, practice has far exceeded theory; and the result to-day in ordinary work is not so much a demand for accurate measurements as some fixed standard with definite results and satisfactory instruments for comparison.

SOME REMARKABLE LOCOMOTIVES OF 1908

By J. F. Gairns

THE record of 1908, as regards the locomotive-building business has, on the whole not been a very good one, though some individual firms have had a fairly prosperous year, and in a few countries, France in particular, large additions have been made to the locomotive stock. In most cases, however, there has been a comparative slump in locomotives, and this is mainly due to the fact that on so many railways new engines of the larger classes have been built in such large numbers for several years past that the demand has fallen off to some extent. In France, the fact that some of the railways have been understocked, or were using an undue proportion of old engines, the acquirement of the Western Railway by the State and the great developments in traffic constitute the main reasons for the large orders for new locomotives given out for delivery in 1907-08-09-10. In the United States new engines have previously been so largely acquired on the various lines that present demands are fairly adequately met, while the industrial and financial difficulties of the country further explain the paucity of orders for new locomotives during 1908. Consequently, the output of the two principal locomotive-building firms, the Baldwin Works and the American Locomotive Company, has been very seriously less than for many years past.

In Great Britain comparatively few new locomotives have been constructed by the railways themselves, and the orders given out have not been specially large. The colonial business has also been slack; and one, if not more of the locomotive-building firms, has suffered considerably from industrial difficulties.

In Germany, Austria, Italy and most of the Continental countries the business done has been fair, partly because a number of firms have obtained orders from France and other countries.

It is, however, with the engineering features of what has been done that we are most particularly concerned. The actual novelties are comparatively few, though the number of interesting designs is considerable, but the main features of the world's locomotive practice in 1908 may be briefly reviewed as follows:

1. The extensive introduction of "Pacific" (4-6-2) locomotives in France, and the initial introduction thereof in England and Germany, both of the latter, however, being really towards the close of 1907, though usually associated with 1908.

2. The extensive introduction and development of articulated locomotives in the United States, and the construction of such locomotives by British and American firms for use in other countries.

3. The somewhat extensive building of locomotives of moderate dimensions for use on railways already using larger engines, these smaller engines in some cases nearly or exactly corresponding in design with engines built some years ago, or being developments of such designs. This has occurred parti-

cularly in Great Britain, but is also characteristic to some extent of Continental railways.

4. The extension of the use of superheating apparatus.

5. The introduction of several new wheel arrangements and of at least one engine which is a very radical departure from usual methods of design.

It will be advisable to follow the example set in previous articles of a corresponding character (CASSIER'S MAGAZINE, MAY, 1907, and May 1908), and adopt a wheel type classification irrespective of nationality, and in a descending scale, according to the number of coupled or driving wheels.

This method of classification calls first for a consideration of the various articulated locomotives.

Although it is only about five years since articulated locomotives were introduced into the United States, they have since been adopted in comparatively large numbers, and several of the most interesting designs have been illustrated and described in these pages. The largest, and so far the most remarkable, are the 0-8-8-0 engines built by the American Locomotive Company for the Erie Railroad and illustrated in last year's article on "Remarkable Locomotives in 1907."

The locomotives already constructed may be dismissed with brief mention, as they have mostly been described fairly extensively. They are as follows: 0-6-6-0, built by the American Locomotive Company for the Baltimore and Ohio Railway (three engines); 0-6-6-0, narrow-gauge engines for Porto Rico, built by the Baldwin Works (three engines); 2-6-6-2, engines constructed by the Baldwin Works for the Great Northern (U. S. A.), Chicago, Burlington, and Quincy, and Northern Pacific Railways (eighty-six engines); 0-8-8-0, engines for the Erie Railroad, built by the American Locomotive Company (three engines); 0-6-6-0, engines for the Central Railway of Brazil, constructed by the American Locomotive Company; 0-6-6-0, engines for San Domingo, built by the Baldwin Works; and a 2-6-6-2 engine for the Mexican Central Railway, built by he Baldwin Works.

FIG. 1.—ARTICULATED LOCOMOTIVE FOR THE CENTRAL RAILWAY OF BRAZIL. BUILT BY THE AMERICAN LOCOMOTIVE COMPANY

Fig. 1 illustrates one of the 0-6-6-0 engines for the Central Railway of Brazil.

It is also under discussion to introduce articulated locomotives for fast passenger service; or rather these will be divided engines, the two sets of coupled wheels being both carried by the main frames. One proposal suggests the 2-4-4-2

FIG. 2.—ARTICULATED COMPOUND ENGINE FOR THE IMPERIAL PEKING-KALGAN RAILWAY, OF NORTH CHINA. BUILT BY THE NORTH BRITISH LOCOMOTIVE CO., LTD.

wheel arrangement, and the other the 4-4-4-2 wheel type.

On the Eastern Railway of France a 2-6-6-0 articulated locomotive has just been supplied from the Schenectady works of the American Locomotive Company.

In Great Britain, Messrs. Kitson & Co., of Leeds, have recently supplied several huge 2-8-8-0 articulated tank engines for the Great Southern Railway of Spain, but these engines use high-pressure steam for all four cylinders. We are unable to illustrate these engines, but their main dimensions are included in the table of dimensions given at the close of this article.

Although a few high-pressure articulated locomotives have been constructed in Great Britain, of which the engines just referred to are the most interesting, the locomotive shown in Fig. 2 is, to the writer's knowledge, the first Mallet compound engine to be constructed in Great Britain.

Three of these engines have been constructed by the North British Locomotive Company, Ltd., to the order of Messrs. J. Whittall & Co., on behalf of the Imperial Peking-Kalgan Railway of North China.

The valve gears are of the Walschaert type, and are adapted to be controlled by means of steam reversing gear, provision being made for independent relative adjustment of

FIG. 3.—ARTICULATED TANK ENGINE FOR THE BONE-GUELMA OF TUNIS. BUILT BY HENSCHEL & SOHN

FIG. 4.—ARTICULATED COMPOUND TANK ENGINE FOR THE PEKING-HANKOW RAILWAY. CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES FORGES, USINES ET FONDERIES OF HAINE, ST. PIERRE, BELGIUM

the cut-off ratios. Steam-actuated drain valves are provided for all cylinders. To assist starting, boiler steam can be admitted to the receiver by means of a pipe controlled by a valve in the cab. The engine is fitted with Westinghouse "automatic" and "non-automatic" air brakes and compressed air sanding apparatus is employed. The dimensions will indicate the large size of these engines which are designed to deal with heavy loads up long grades of 1 in 30 and round curves of 500 feet radius. The total axle-load is 16 tons, and the total weight of the engine is 96 tons, all of which is, of course, utilized for adhesion. The tenders have been constructed in China.

Articulated engines, both tender and tank, have been used for many years in Continental countries. A large and interesting engine of this class, constructed by Messrs. Henschel & Sohn, of Cassel, Germany, for the Bone-Guelma Railway of Tunis (metre gauge) is shown in Fig. 3.

A few years ago Mons. du Bousquet introduced a series of 0-6-2-2-6-0 articulated compound tank engines for heavy mineral traffic on the Northern Railway of France. These engines are still among the most remarkable in the world and the design is the only one possessing this wheel arrangement, while they are unique as regards some of the constructional features. During 1908

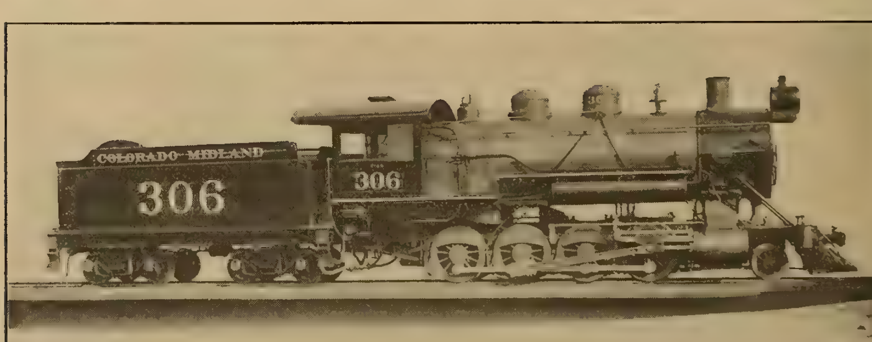


FIG. 5.—2-8-0 LOCOMOTIVE FOR THE COLORADO MIDLAND RAILWAY. BUILT BY THE BALDWIN WORKS

several engines to practically the same drawings were constructed by the Société Anonyme des Forges, Usines et Fonderies of Haine, St. Pierre, Belgium, for the Peking-Hankow Railway of China, and one of these is illustrated in Fig. 4. There are two pivoted frames, each having six coupled wheels and a pair of carrying wheels provided near the centre of the engine mainly for the purpose of supporting the cylinders. One pair of cylinders uses high-pressure steam and the other low-pressure steam, the necessary flexible connections of the steam pipes being effected by ball and socket and telescopic joints. In view of the high-steam pressure to which some of these are subjected, special constructions had to be introduced, but it is understood that no trouble has been experienced from this cause.

Dealing now with ten-coupled engines there is very little to record in the way of novelty, but such engines have been introduced into Bulgaria, a large 0-10-0 class having been constructed by the firm of A. Borsig, of Tegel-bei-Berlin, and new engines of the 0-10-0 and 2-10-0 classes have been introduced in Austria, where such engines have been used for mountain traffic for several years.

To a great extent the 2-8-0 or "Consolidation" type is so much a standard type now in all parts of the world that there can be little of special interest, although many of the engines are large and powerful machines. But a few examples of practice in this connection may be referred to.

Fig. 5 illustrates an engine built by the Baldwin Works for the Colorado Midland Railway, and employed in freight service in the Rocky Mountains. This road has maximum grades on the main line of 4 per cent. and curves of 16 degrees.

In order to assist the engine in curving, the driving-wheels are compactly grouped, and the second and third pairs have plain tires without flanges. The engine truck is equipped with a swing bolster and radius bar, provision being made for a swing of 4¼ inches on each side of the centre line. The truck is equalized with the first pair of driving-wheels by means of a cast steel equalizing beam, which has its fulcrum on the center line of the locomotive under the cylinder saddle casting. The three remaining pairs of driving-wheels are equalized together, on each side of the locomotive. The frames are of cast steel of the bar type, with double front rails of wrought iron.

Fig. 6 illustrates a 2-8-0 locomotive, built by the Baldwin Works for the White Pass and Yukon route, and this is interesting not only on account of its design, but also because of its exceptional weight and

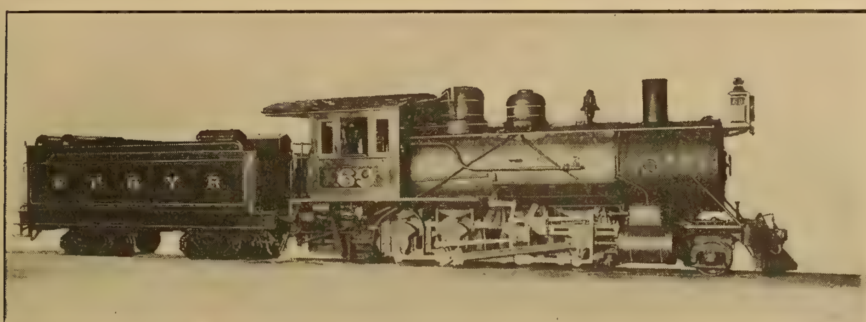


FIG. 6.—NARROW-GAUGE 2-8-0 ENGINE FOR THE WHITE PASS AND YUKON RAILWAY. BUILT BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.

FIG. 7.—2-8-0 ENGINE FOR THE EAST INDIAN RAILWAY. BUILT BY THE VULCAN FOUNDRY CO., LTD.

power for an engine of 3 feet gauge. The line is laid with rails weighing 56 pounds per yard; the maximum grades are 3.9 per cent., and the sharpest curves have a radius of 286 feet. The locomotive uses moderately superheated steam at a comparatively low pressure.

The loads on the first and second pairs of driving-wheels are equalized with the engine truck, while the third and fourth pairs of driving-wheels are separately equalized. The two intermediate pairs of driving-wheels have plain tires without flanges.

The superheater is of the smoke-box type, as developed by the Baldwin Locomotive Works. It consists of two upper and two lower drums connected by curving rows of tubes which follow the contour of the smoke-box shell. The two upper drums receive steam direct from the dry pipe, while the lower drums communicate with the live-steam passages leading to the cylinders. The steam flows successively through different groups of tubes and abstracts as much heat as possible from the waste gases, which are compelled to circulate among the tubes by suitably arranged deflecting plates.

Two or three years ago a Locomotive Standards Committee submitted proposals for standard types and dimensions for British Colonial locomotives, and since then most of the engines constructed for Indian railways have been designed in general accordance with these proposals. Among these designs were

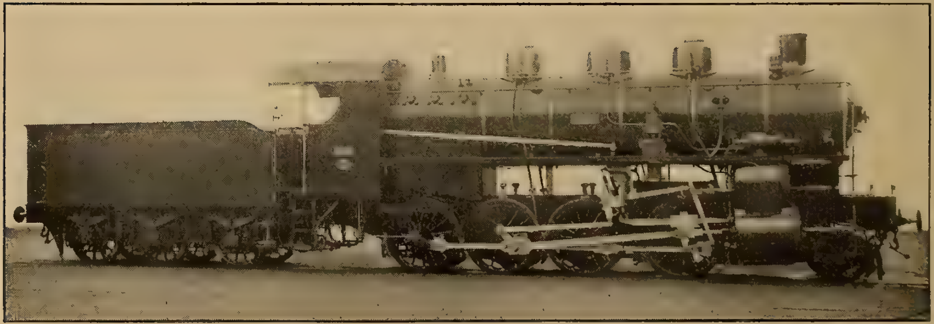


FIG. 8.—2-8-0 DE GLEHN COMPOUND ENGINE FOR THE WESTERN RAILWAY OF FRANCE. HENSCHEL & SOHN, CASSEL, GERMANY

included those for engines of the 4-6-0, 4-4-2 and 2-8-0 types, and examples of all these, together with a 0-6-4 tank engine, will be referred to in this article, but for the present the 2-8-0 design only is dealt with. Fig. 7 illustrates a fine engine of this type constructed by the Vulcan Foundry Company, Ltd., for the East Indian Railway, and this well sets forth the principal characteristics of the standard designs referred to. The gauge is 5 foot 6 inches, and this admits of large dimensions being employed, especially as the loads to be hauled over severe gradients are frequently very considerable.

Large goods engines of the 2-8-0 type, and compounded according to the De Glehn system, are employed on most of the French railways, and a recent example as constructed by Henschel and Sohn, of Cassel, Germany, for the Western Railway of France, is shown in Fig. 8. The design is a development of a previous and smaller class, but otherwise does not call for special reference.

Previous to 1907 the 4-6-2 or Pacific type was almost entirely confined to American practice, the only exceptions known to the writer being a series of 4-6-2 narrow-gauge engines for the Federated Malay States Railways, the first 4-6-2 engines for the Paris-Orleans Railway in France, both of which designs were illustrated in CASSIER'S MAGAZINE for May, 1908, and some large South African narrow-gauge examples. At the close of 1907, however, the type was introduced in Germany and in Great Britain, but the developments in Germany have not been great, while there is still only the one engine in England. In France, however, the type has been used for large numbers of locomotives on several railways, and a considerable number are on order, notwithstanding that it is so short a time since the introduction of the type.

Probably the most important reason for the adoption of the 4-6-2 type is that, like the 4-4-2 type, to which it corresponds, the design of firebox is unrestricted by large wheels, whereas in the 4-6-0 and 4-4-0 types the firebox has to be fitted between or over a pair of coupled wheels, with consequent restrictions if the wheels are of fairly large diameter. As the developments in boiler design relate primarily to the firebox, and only secondarily to length of barrel, it follows that the adoption of a wheel type, including a pair of trailing wheels, is almost inevitable; while the increase of weight consequent upon increased dimensions calls for additional wheels for supporting.

FIG. 9.—PACIFIC TYPE LOCOMOTIVE. BADEN STATE RAILWAY. J. A. MAFFEI, MUNICH, GERMANY

Fig. 9 illustrates the first of the German engines referred to, constructed by the firm of J. A. Maffei, of Munich, for the Baden State Railways.

Recent locomotive design in Baden and Bavaria, and also to some extent in other German states where locomotives are supplied by the firm

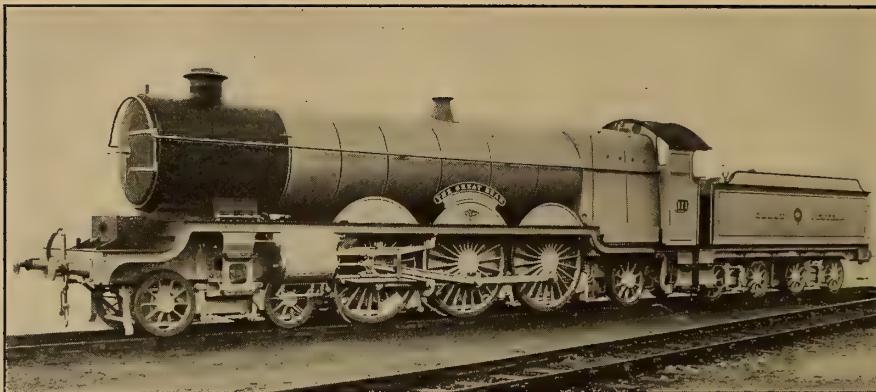


FIG. 10.—4-6-2 LOCOMOTIVE, "THE GREAT BEAR," FOR THE GREAT WESTERN RAILWAY. DESIGNED BY MR. G. J. CHURCHWARD

of J. A. Maffei, has comprised a number of special characteristics, and the present design is really a development of these designs. Both in Baden and Bavaria large 4-4-2 and 4-6-0 engines having the same general features are in use. They have bar framing of the American type; they are four cylinder compound engines, all cylinders driving the leading coupled wheels and two sets of valve gear only being employed, while the starting mechanism is of the Maffei type, providing for non-compound working when the reversing lever is placed in full, or nearly full, forward or backward gear; they have large barrelled boilers, with a wide firebox (the firebox of the 4-6-0 engines is of narrower design than in the case of the 4-4-2 engines), and a large extended smokebox; and there are also other distinctive constructional features. About two years ago a 4-4-4 express design was also introduced. This constituted a development of the 4-4-2 design with larger boiler and larger dimensions, a bogie being fitted at the rear for carrying purposes and for flexibility. In this design the conical smoke-box, wedge-shaped cab and engine front, and the combined steam dome and sandbox in a wedge-shaped casing, which are characteristic of the engine illustrated, were also included. Consequently the locomotive now described may be considered a development of all of these designs.

The fire box is of the round-topped, wide type, with sloping front, and the ashpit is rather unusually arranged. There are four safety valves. The boiler is of large diameter and considerable length, and a Schmidt smoke-tube superheater is employed. The cylinder

FIG. 11.—NARROW-GAUGE LOCOMOTIVE, BENGAL-NAGPUR RAILWAY. NORTH BRITISH LOCOMOTIVE CO., LTD.

castings form a saddle for supporting the smoke-box. The outside cylinders (low pressure) are arranged horizontally, but the inside cylinders (high pressure) are arranged at a considerable inclination, to enable the connecting rods to clear the leading coupled axle; and, for the same reason, the stroke of the inside cylinders is less than that of the outside cylinders. Large piston valves are employed for controlling the steam distribution. A special supporting frame, similar to that used in some American designs, is employed for supporting the expansion links of the Walschaert valve gear. A speed indicator is operated from the rear coupling pin on one side. All wheels are provided with brake blocks. The tender is supported on diamond frame bogies, and is provided with extra large water tanks. Equalizing levers are employed between the three coupled axles.

The only 4-6-2 locomotive in Great Britain appeared at the close of 1907 on the Great Western Railway, being designed by Mr. G. J. Churchward. This remarkable engine is illustrated in Fig. 10. It is a development of the "Star" class of 4-6-0 four-cylinder, non-compound express locomotives which are doing such fine work, and is appropriately named "The Great Bear." In many respects it is based on standard practice, but with larger cylinders. The boiler, although based on usual Great Western Railway methods, is somewhat remarkable. The centre line is 9 feet above rail level, the barrel is 23 feet long and 5 feet 6 inches diameter at the smallest ring, connected by a taper or coned section, with a 6-foot ring. The firebox is of the Belpaire type. In the smoke-box a Swindon superheater is placed, this being a modification of the Schmidt smoke-tube apparatus, but with several interesting and valuable features of construction.

Fig. 11 illustrates a rather interesting narrow-gauge engine built by

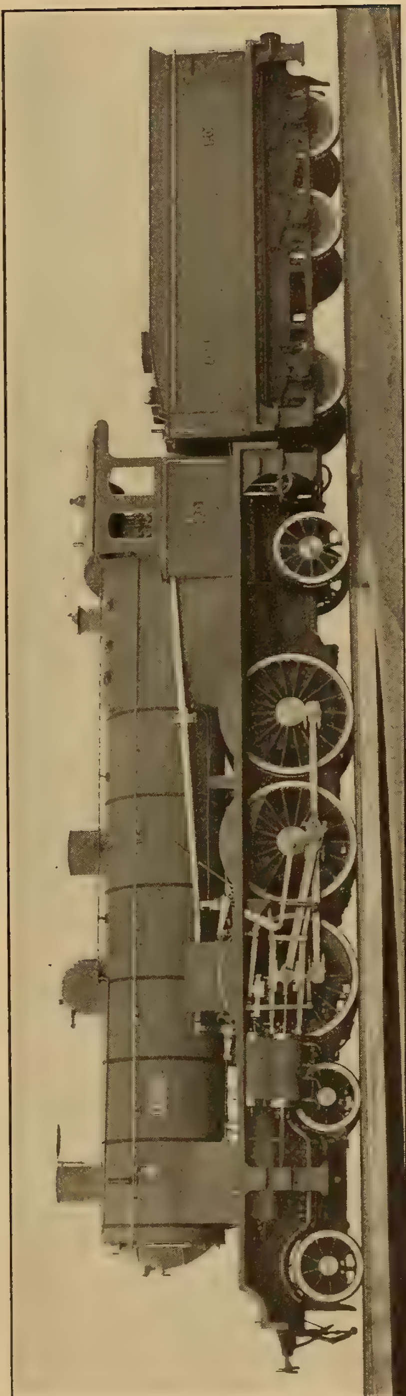


FIG. 12.—PACIFIC TYPE OF DE GLEHN COMPOUND LOCOMOTIVE FOR THE PARIS-ORLEANS RAILWAY. BUILT BY THE AMERICAN LOCOMOTIVE CO.

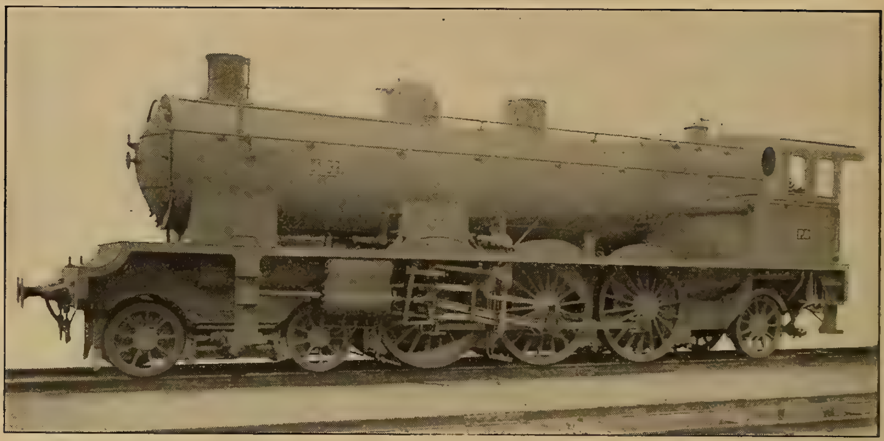


FIG. 13.—PACIFIC TYPE DE GLEHN COMPOUND LOCOMOTIVE FOR THE PARIS-ORLEANS RAILWAY. BUILT BY THE HANOVER ENGINEERING CO.

the North British Locomotive Company, Ltd., for use on the narrow gauge (about 370 miles of 2 feet 6 inches gauge) sections of the Bengal-Nagpur Railway of India. The wheels are placed between the frames owing to the narrowness of the gauge. The rear axle is fitted in a pivoted truck, so that the rigid wheelbase is very short. In view of the narrow gauge the dimensions of these engines are considerable.

As already stated, it is on the French lines that the principal introductions of 4-6-2 locomotives have occurred, and it is necessary to deal with them at somewhat greater length. The first engine described in last year's article was for the Paris-Orleans Railway, and for that line a larger number of engines have since been constructed by various firms, not only French, but also German and American, all of them, however, being constructed to the railway company's drawings.

Fig. 12 illustrates one of these engines as constructed by the American Locomotive Company.

These locomotives are of the four-cylinder balanced compound type, the four-cylinders being compounded and arranged on the De Glehn system. The high-pressure cylinders are fitted with piston valves, and the steam pipes to the high-press-

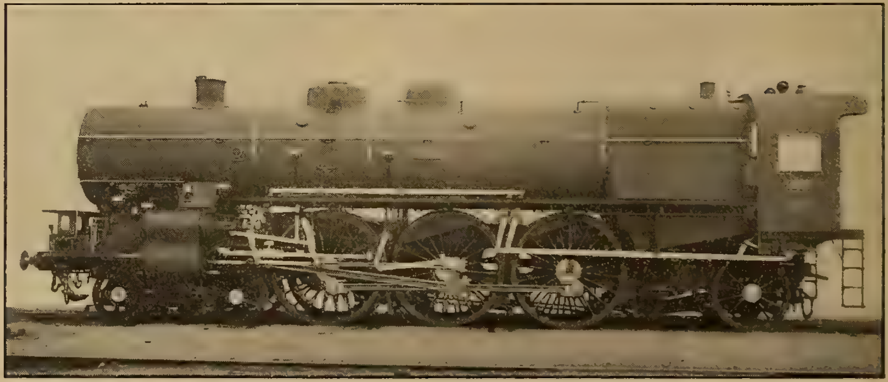


FIG. 14.—PACIFIC TYPE DE GLEHN COMPOUND EXPRESS LOCOMOTIVE FOR THE WESTERN RAILWAY OF FRANCE

ure cylinders are located in the smoke-box instead of being outside the boiler.

The low-pressure cylinders are between the frames underneath the smoke-box and drive on the cranked axle of the leading driving wheels, while the high-pressure cylinders are placed outside of the frames some distance behind the low-pressure cylinders and are connected to the centre pair of driving-wheels.

The two low-pressure cylinders, together with their steam chests and a receiver, are formed within one casting. The low-pressure valves are plain slide valves.

Fig. 13 illustrates a similar locomotive built by the Hanover Engineering Company, of Linden-Hanover, Germany.

Engines of similar design have been introduced on most of the other French lines, but on the Western Railway they are even larger and more remarkable, as shown by Fig. 14. These engines have been constructed at the Railway Works. The dimensions of the boiler are particularly notable. Some of these engines have been fitted with the Schmidt superheater. The smoke-box is extended to a degree that is probably unique. The huge Belpaire firebox widens out over the frames towards the base. The cylinders are compounded according to the De Glehn system, but piston valves are used for all of them.

The piston valve appears thus to be meeting with extensive use not only for the high-pressure cylinders of compound engines, but for the general steam distribution, both in the high and low-pressure cylinders.

Of late years most of the largest locomotives used in Austria have been four-cylinder compounds according to the Gölsdorf system, of the 4-4-2, 2-6-2, 2-10-0 and 0-10-0 wheel types; but Herr von Gölsdorf, the chief locomotive engineer of the Austrian State Railways, has now introduced a new design having a wheel arrangement (2-6-4) that has not hitherto been employed anywhere, to the writer's knowledge, for tender engines. The first of these engines is illustrated in Fig. 15 by the courtesy of Herr Gölsdorf. The design is a development of the

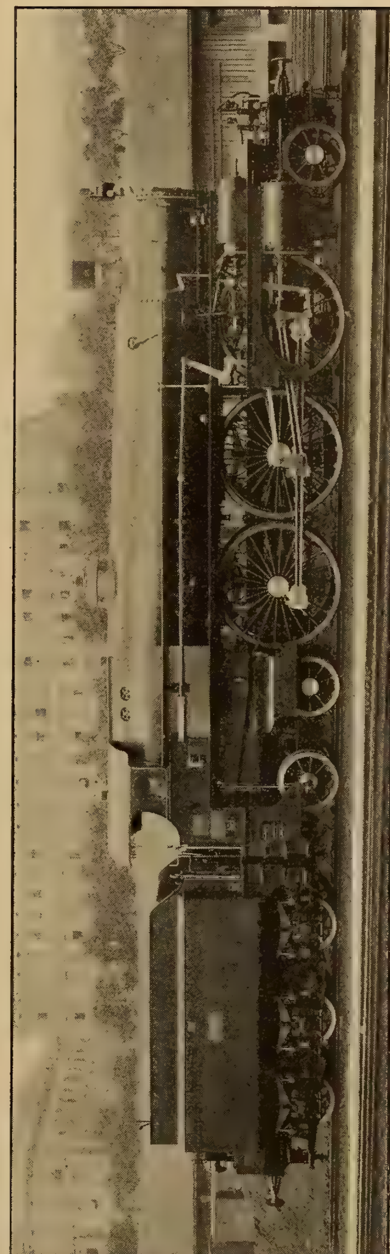


FIG. 15.—NEW 2-6-4 EXPRESS LOCOMOTIVE FOR THE AUSTRIAN STATE RAILWAYS

FIG. 16.—2-6-2 EXPRESS LOCOMOTIVE FOR THE ITALIAN STATE RAILWAYS. BUILT BY ERNESTO BREDA, OF MILAN

2-6-2 engines already in service, but owing to the dimensions of the boiler the trailing axle is replaced by a four-wheeled truck under the wide round-topped firebox. The front portion of the boiler barrel is partitioned off to form a Clench superheater. This is divided vertically by transverse partitions, the boiler tubes passing through these partitions, the steam passing up and down as guided by the partitions before passing to the cylinders, and being superheated by the heat transmitted from the boiler tubes. The inside cylinders are placed at a higher level and inclined so that the rods clear the front coupled axle. The steam distribution is controlled by large piston valves located above the outside cylinders.

As regards the 2-6-2 wheel type, a number of additional engines have been constructed in Austria and Italy, particularly in the latter country, but the type does not appear to be greatly in favour. In last year's article a 2-6-2 engine belonging to the Italian State Railways was described, and in Fig. 16 a later engine of the same class is illustrated. This engine is notable as being the 1000th built by the firm of Ernesto Breda, of Milan.

During 1908 a remarkable engine was introduced on the English Mid-

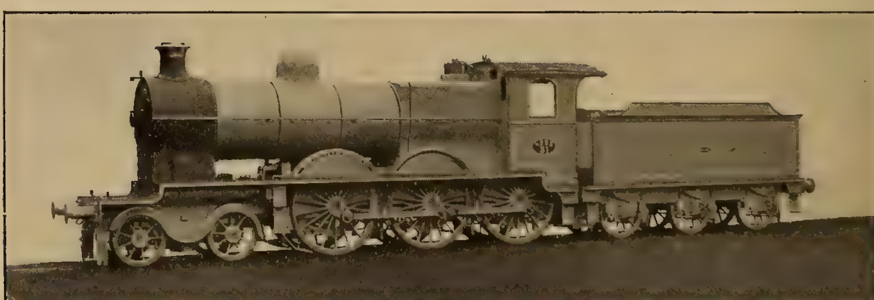


FIG. 17.—4-6-0 EXPRESS LOCOMOTIVE FOR NORTH-BRABANT RAILWAYS. BEYER, PEACOCK & CO., LTD., MANCHESTER

land Railway of the 2-6-2 type, and this should be the biggest novelty of the year, though official particulars are at present withheld, as it comprises so many special features and is purely experimental. Apparently, it has a huge boiler, with two firedoors and two sets of four single-acting cylinders, two cylinders driving the first coupled axle, two the rear coupled axle and two from either side driving the middle coupled axle.

It is now necessary to consider the 4-6-0 type, which is still one of the most frequently employed, though there are not many new designs and not a great number of these engines have been constructed during 1908. There is little to remark as regards British practice, except that on the Great Western Railway of England Mr. Churchward has introduced a further series of 4-6-0 four-cylinder, non-compound engines, and these are fitted with the Swindon superheater, some further 4-6-0 four-cylinder, non-compound engines have been introduced by Mr. D. Drummond on the London & South Western Railway, and some 4-6-0 four-cylinder, non-compound engines have been introduced by Mr. G. Hughes on the Lancashire, Yorkshire Railway.

Fig. 17 illustrates a large 4-6-0 engine, recently supplied by the builders, Messrs. Beyer, Peacock & Co., Ltd., for the North Brabant Railways in Holland. These fine engines, besides being of large size, are interesting examples of advanced locomotive-engineering practice, and are further remarkable because they are, we believe, the only express passenger engines of the 4-6-0 type so far introduced on Dutch railways. The influence of British practice in the design of these engines as regards the use of inside cylinders, general neatness and apparent simplicity, is in marked contrast with the locomotives of many other Continental railways.

Balanced slide valves placed above the cylinders are used, and they are actuated by Walschaert valve gear, equalizing levers are employed for the coupled wheels, and a pair of two-column Ramsbottom safety valves are fitted on the large Belpaire firebox. In designing these engines, the load on any axle had to be kept within 14 metric tons.

FIG. 18.—4-6-0 LOCOMOTIVE FOR THE EAST INDIAN RAILWAY. CONSTRUCTED BY THE VULCAN FOUNDRY CO., LTD.

Reference has already been made to the Locomotive Standards which have been largely adopted in British colonial practice, and Fig. 18 illustrates a fine 4-6-0 engine built by The Vulcan Foundry for the East Indian Railway in accordance therewith.

Fig. 19 illustrates a large 4-6-0 express locomotive for the Paris-Lyons-Mediterranean Railway constructed by Messrs. Henschel and Sohn, of Cassel. These fine engines are four-cylinder compounds according to the Henri-Baudry system, with large Belpaire fireboxes,

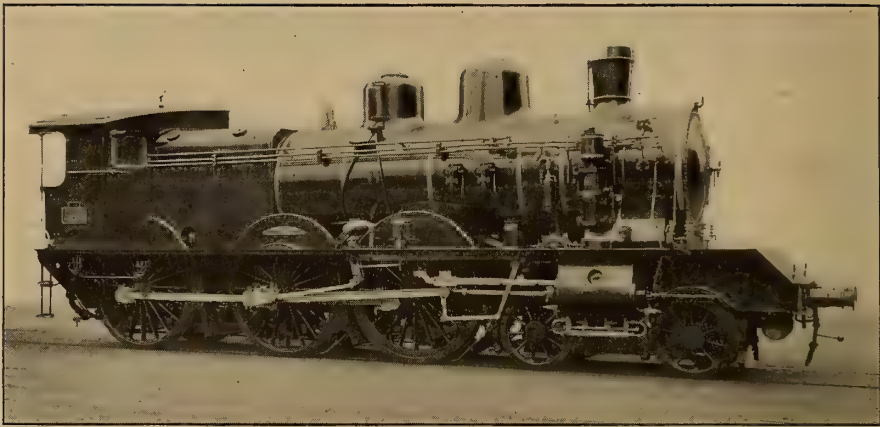


FIG. 19.—4-6-0 FOUR-CYLINDER COMPOUND EXPRESS LOCOMOTIVE WITH SCHMIDT SUPERHEATER, PARIS-LYONS MEDITERRANEAN RAILWAY. BUILT BY HENSCHEL & SOHN

and they are fitted with the Schmidt smoke-tube superheater.

Fig. 20 illustrates a large 4-6-0 express engine, recently constructed to the designs of Mr. F. H. Trevethick by the North British Locomotive Company for the Egyptian State Railways. This engine is fitted with Mr. Trevethick's special arrangement of feed-water heating apparatus. There are two heating drums through which steam from the air and feed pumps and a little exhaust steam is passed; and the water then passes to a heater fitted round the inside of the smoke-box. This apparatus has now been very thoroughly tested, and appears to be very satisfactory in service. A model of this engine attracted considerable attention at the Franco-British Exhibition in London.

Dealing now with the 4-4-2 or Atlantic type locomotives, Fig. 21 illustrates one of these engines as constructed for the East Indian Railway by the Vulcan Foundry Company. In most respects these engines correspond very closely with the 4-6-0 and 2-8-0 engines for this railway already referred to.

Fig. 22 illustrates an engine which is of special interest. The builders are the North British Locomotive Company, and the engine has been supplied for working on the broad (5 feet 6 inches) gauge lines of the Bengal-Nagpur Railway in the fastest express and mail services. The engine is compounded on the de Glehn system and has been supplied on trial conditions, the arrangement being, we believe, that if the officials are not satisfied with the performances of the engine for twelve months in regular service, the engine may be returned to the makers. This contingency appears to be

FIG. 20.—4-6-0 EXPRESS LOCOMOTIVE FOR THE EGYPTIAN STATE RAILWAY, FITTED WITH MR. TREVETHICK'S FEED-WATER HEATING APPARATUS. NORTH BRITISH LOCOMOTIVE WORKS

somewhat unlikely; but, as this is the first instance of a De Glehn compound engine in India, where the two-cylinder compound engine, once in considerable favour, is disappearing, the occurrence is worthy of note.

Fig. 23 illustrates a new design constructed by the Hanover Engineering Company for the Prussian State Railways. The main features of the construction of this engine are identical with those of the well-known earlier type. All proportions of the later type have, however, been increased as far as possible, the boiler in particular having considerably larger dimensions. The locomotive is of the four-cylinder, compound type, after the von Borries system. The high-pressure cylinders are placed outside, whilst the low-pressure cylinders are inside the frame. The front part of the latter is constructed as a bar frame. As opposed to the earlier type, the high and low-pressure cylinders of this engine are fitted with piston valves.

As regards the smaller types there is little to remark, though a considerable number of such engines have been constructed, but it will be in place to refer to a few engines of the 4-4-0 type.

Fig. 24 illustrates one of the latest engines of the South Eastern & Chatham Railway. Since the first introduction by Mr. Wainwright of this design, several modifications have been made, so that there are in use on this railway a large number of engines having the same main characteristics, and nearly the same dimensions, but belonging to several distinct series differentiated from one another in minor respects. The principal difference is that some of them have ordinary round-topped fireboxes and others have Belpaire fireboxes, and while the earlier engines have 6-foot 8-inch coupled wheels, the standard wheel diameter is now 6 feet 6 inches. The engine illustrated represents the latest development of the design, with Belpaire firebox and extended smoke-box, and is further interesting because this actual locomotive was the only full-sized locomotive exhibited at the Franco-British Exhibition in London. These engines have only moderate dimensions as locomotive dimensions go nowadays, but they do some very fine work. Many of the trains weigh nearly or quite 300 tons, and they work over the hardest main lines out of London; consequently, their performances, even with average speeds of under 50 miles per hour with the best trains, must be reckoned as very

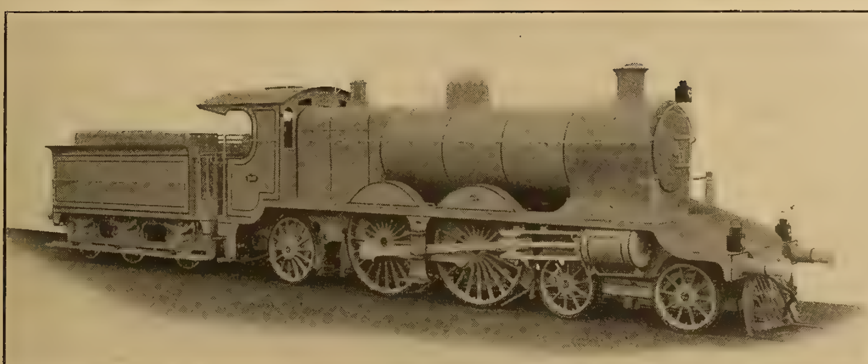


FIG. 21.—4-4-2 EXPRESS LOCOMOTIVE FOR THE EAST INDIAN RAILWAY, BUILT BY THE VULCAN FOUNDRY CO., LTD.

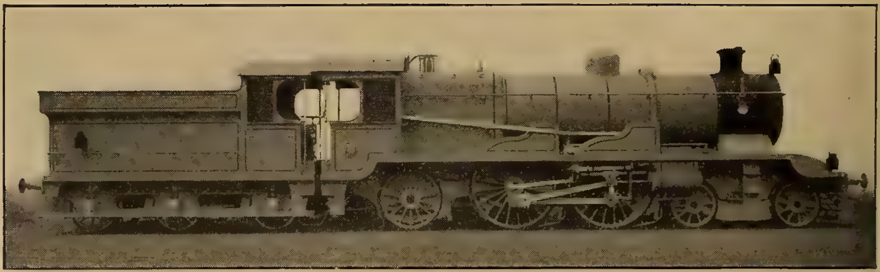


FIG. 22.—DE GLEHN COMPOUND EXPRESS LOCOMOTIVE, LENGAL-NAGPUR RAILWAY. BUILT BY THE NORTH BRITISH LOCOMOTIVE CO.

praiseworthy under the conditions.

On the Highland Railway a new class of 4-4-0 engines was introduced in 1908. These are large-boilered versions of Mr. P. Drummond's ordinary inside-cylindered 4-4-0 engines, and they do very good work over the mountain grades of the south main line of the Highland Railway in Scotland. It is worthy of remark that several British Railways have constructed during 1908 quite a number of 4-4-0 and other engines of designs that have apparently been superseded by 4-4-2 and 4-6-0 engines, mainly for dealing with secondary traffic and on sections where the largest engines are not allowed, but these engines are also used to a considerable extent on the ordinary and even the principal main line train services. On the North Eastern Railway, for example, a number of such engines have been placed in service, also large-boilered 0-6-0 mineral engines, notwithstanding that the 4-4-2, 4-6-0 and 0-8-0 engines of this line are among the most remarkable in Great Britain; and at the close of 1908, a new class of large-boilered 4-4-0 engines were introduced by Mr. Worsdell.

On the Great Western Railway a further series of the one-time famous "Atbara" class has been introduced, and one of these is illustrated in Fig. 25. The new engines are all named after flowers, with names such as "Primrose," "Calceolaria," "Stephanotis," "Petunia," etc., and some of these names appear rather incongruous when associated with locomotives.

On the Prussian State Railways 4-4-0 engines are still largely employed. They are fitted, as are so many of the Prussian State engines,

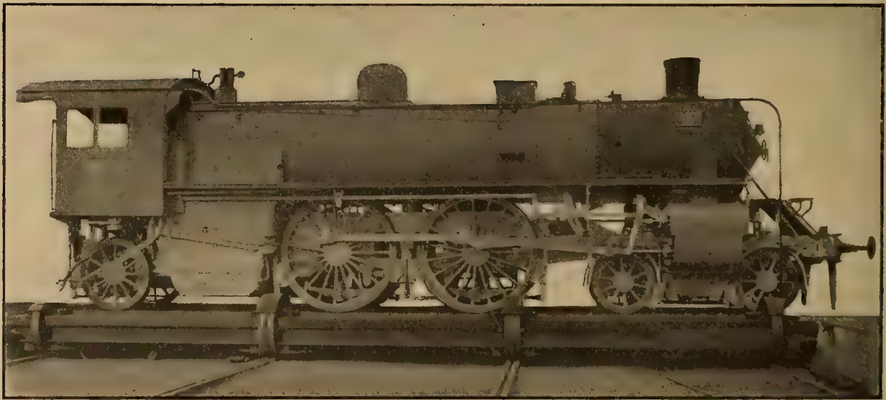


FIG. 23.—4-4-2 FOUR-CYLINDER COMPOUND EXPRESS LOCOMOTIVE, PRUSSIAN STATE RAILWAY. CONSTRUCTED BY THE HANOVER ENGINEERING CO.

FIG. 24.—4-4-0 EXPRESS LOCOMOTIVE, SOUTH-EASTERN & CHATHAM RAILWAY. EXHIBITED AT THE FRANCO-BRITISH EXHIBITION

with the Schmidt smoke-tube superheater, and it is claimed, apparently with good reason, that they can do as good work as many larger engines of other types.

As regards the ordinary six-coupled goods type, there is little to remark, as the type does not usually admit of any special developments, but one example of practice in 1908 may be referred to.

Fig. 26 illustrates one of a new class of engine introduced on the Great Northern Railway of England by Mr. H. A. Ivatt, and intended for working express goods, mixed traffic and heavy excursion trains. The design is an adaptation of the 0-6-2 tank engine illustrated in last year's article, and the coupled wheels (5 feet 8 inches) have a diameter that is rather unusual for this type.

It is necessary now to deal with the tank engine. One of the most interesting features of modern locomotive-engineering practice is the increasing favour of tank engines of large size, not only for suburban and branch traffic, but also for dealing with some of the work that is usually reckoned as correctly within the province of express and other tender engines.

There have been hardly any Continental tank engines which call for special remark having four coupled wheels, but reference to British practice in this connection is necessary because of the extending use of such engines, in all cases of the 4-4-2 type, for express traffic with moderately long runs between stops. On many lines tank engines, with coupled wheels about 5 feet 6 inches or 5 feet 8 inches diameter, are extensively used for semi-fast traffic,

FIG. 25.—NEW 4-4-0 LOCOMOTIVE, GREAT WESTERN RAILWAY, SWINDON WORKS

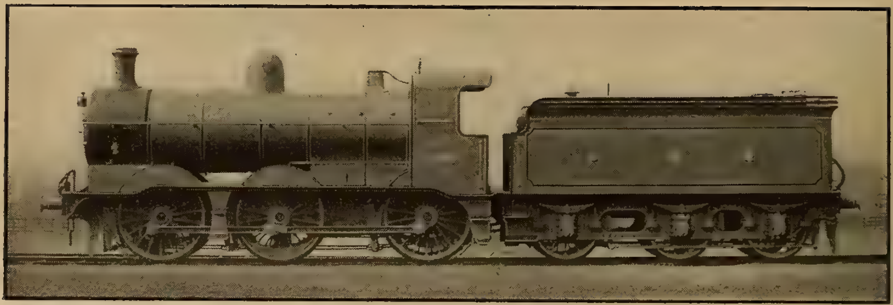


FIG. 26.—NEW EXPRESS GOODS ENGINE. GREAT NORTHERN RAILWAY, DONCASTER WORKS

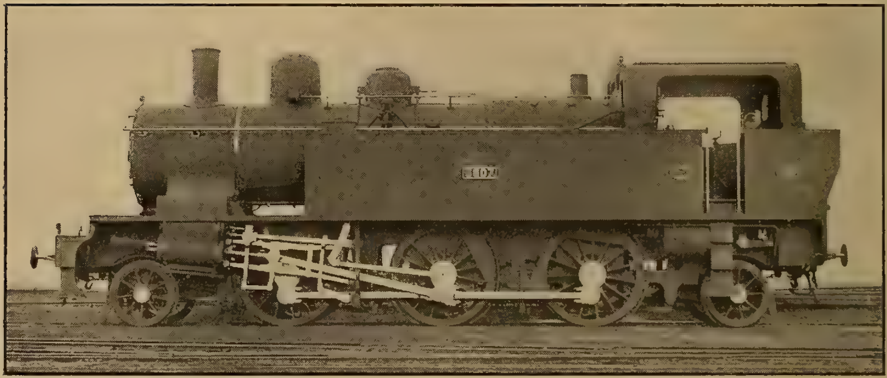


FIG. 27.—2-6-2 COMPOUND TANK ENGINE, WESTERN RAILWAY OF FRANCE. CONSTRUCTED BY THE SOCIÉTÉ ALSACIENNE DE CONSTRUCTIONS MÉCANIQUES

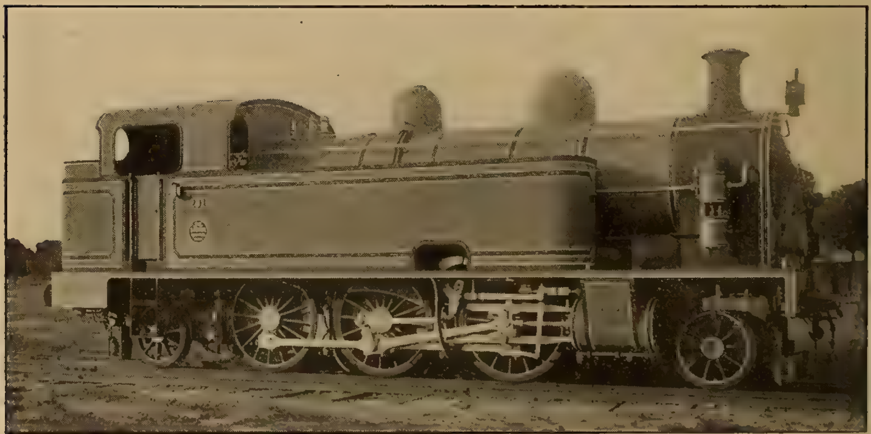


FIG. 28.—2-6-2 TANK ENGINE FOR THE PRINCE HENRY RAILWAY, OF LUXEMBOURG. BUILT BY A. BORSIG, OF TEGEL-BEI-BERLIN

FIG. 29.—0-6-4 TANK ENGINE, EAST INDIAN RAILWAY. BUILT BY VULCAN FOUNDRY CO., LTD.

but there is a very decided tendency to use engines of this class with large wheels. Thus there are 4-4-2 tanks on the Great Western Railway, with 6-foot 8-inch wheels; on the London and North Western Railway, with 6-foot 3-inch wheels, and on the London Tilbury & Southend Railway, with 6-foot 6-inch wheels, all of these being very large engines, capable of really fast main line work.

On the London Brighton & South Coast Railway, Mr. D. Earle Marsh introduced about two years ago a class of 4-4-2 tank engine for suburban service, and in 1908 he introduced two classes of express tank engine, one having coupled wheels, 6 feet 9 inches diameter, and the boiler of the standard 4-4-0 express-engines; and the other, with 6-foot 7½-inch coupled wheels, corresponding more with the 4-4-2 express engines, and fitted with the Schmidt superheater. The two original engines of these classes were frequently employed for the principal express trains, including the Sunday Pullman Limited and the new train, "The Southern Bells" (claimed, and with good reason, to be the finest train in the world), both of which are booked non-stop between

FIG. 30.—2-6-4 TANK ENGINE FOR THE MANCHURIA RAILWAYS. BUILT BY THE AMERICAN LOCOMOTIVE CO.

Victoria and Brighton (50½ miles) in 60 minutes, over a road that is by no means easy, besides working other principal expresses, some of them very heavy and fast. The use of tank engines for these trains is of itself remarkable, especially as some very fine performances have been recorded.

As regards six-coupled tank engines, several interesting items must be referred to.

Fig. 27 illustrates a fine 2-6-2 tank engine constructed by La Société Alsacienne de Constructions Mécaniques at the Belfort Works, for the Western Railway of France. These engines are compounded in accordance with the de Glehn system, but all four cylinders drive the centre coupled wheels.

Fig. 28 illustrates a remarkably neat design of 2-6-2 tank engine constructed by the firm of A. Borsig, of Tegel-bei-Berlin, for the Prince Henry Railway of Luxembourg. They are intended to deal with trains of 210 tons at speeds of up to 45 miles per hour on the level or at speeds of 20-25 miles an hour up long banks of 1 in 60, though it is understood that these conditions have been fulfilled with trains of 300 tons. They can carry sufficient water for comparatively long runs between stops and are designed so as to be equally suitable for running in either direction.

On the North Eastern Railway of England, Mr. Wilson Worsdell has introduced a class of 4-6-0 tank engines of interesting design, though we are not able to illustrate one of them. This type is almost unique in Great Britain, and is not very extensively used elsewhere. They are designed for dealing with trains on certain very curved and steeply-graded branches.

FIG. 31.—0-8-4 THREE-CYLINDER SHUNTING TANK ENGINE, GREAT CENTRAL RAILWAY

Referring again to the Locomotive Standards Committee's designs for Continental locomotives, Fig. 29 illustrates a 0-6-4 tank engine constructed according to these proposals by the Vulcan Foundry Company, Ltd., for the East Indian Railway (5-foot 6-inch gauge).

One of the after effects of the Russo-Japanese war has been the modernization of the railways of Manchuria, and a large number of locomotives have been ordered, and many are already delivered, from the American Locomotive Company. In-

cluded among them are sixty-nine tank engines of the 2-6-4 type, and one of these is illustrated in Fig. 30. In many respects the design corresponds to that of the large order recently completed by the same builders for the Panama Railroad, but they are smaller. The design is simple and neat. Equalizing levers are employed for the coupled wheels, and the leading bogie truck. The large tanks accommodate 3,500 gallons of water and six tons of coal can be carried.

Finally, reference must be made to one of the most remarkable locomotives of the year.

"Gridiron" gravity-sorting sidings provide a very convenient means of sorting rapidly a large volume of mineral traffic, and very large concentration sidings of this class at Wath-on-Dearne were brought into use by the Great Central Railway early in 1908. The principle of these sidings is that a train is pushed over a "hump," the wagons being uncoupled in sections according to destination, so that they run down by gravity, and are turned into appropriate tracks by the signalman. At these sidings there are thirty sorting tracks, and 10,000 or 12,000 wagons can be dealt with in the course of a day's work.

The coal trains are mostly hauled

DIMENSIONS OF LOCOMOTIVES REFERRED TO.

C. = Compound. A. = Articulated. T. = Tank. S. = Superheater. N. = 3 or 4 cylinder non-compound.

	Country.	Railway.	Type.	Cylinders (ins.).	Coupled Wheels.	Heating Surface (sq. ft.).	Steam Pressure (lbs. per sq. in.)	Adhesion Weight (tons).	Total Weight (tons).	Remarks.
1	Brazil.....	Central....	0–6–6–0 A.C.	17½ / 28 x 26	4′ 2″	....	200	92	92	
	Spain	Great Southern	2–8–8–0 A.J.N.	14¾ x 24′	4′ 0″	....	180	93	101	
2	China......	Peking-Kalgan.......	0–6–6–0 A.C.	18 / 28¾ x 28	4′ 3″	2,591	200	96	96	
3	Tunis......	Bone-Guelma........	0–6–6–0 T.A.C.	15 / 22¾ x 22	3′ 6″	1,089	213	61	61	Metre gauge
4	China......	Peking-Hankow......	0–6–2–2–6–0 T.A.C.	15¾ / 24¾ x 26¾	4′ 9″	2,625	227	..	102	
5	U. S. A.....	Colorado Midland....	2–8–0	....	......	.....	...	...	....	3′ ft. gauge.
6	U. S. A....	White Pass & Yukon.	2–8–0– S.	....	....	.....	...	...	....	5′ 6″ gauge.
7	India..	East Indian..........	2–8–0	20 x 26	4′ 6″	1,825	180	59	65	
8	France.....	Western.............	2–8–0 C.	19¼ / 29½ x 27½	4′ 4″	2,160	227	51	65	
9	Germany...	Baden State..........	4–6–2 C.S.	17 x 24⅜ / 26 x 26¾	6′	2,793	227	46	85	
10	England....	G. W. R.............	4–6–2 N.S.	15 x 16	6 8½″	3,400	225	61¼	97¼	
11	India.......	Bengal-Nagpur.......	4–6–2	14½ x 18	3′ 6″	1,039	160	20½	33¼	2′ 6″ gauge.
12 / 13	France.....	Paris-Orleans........	4–6–2 C.	15¾ / 25 x 25⅝	6′ 0″	3,048	227	53	89½	
14	France.....	Western.............	4–6–2 C.S.	....	....	.....	...	...	....	
15	Austria.....	State................	2–6–4 C.S.	15½ / 26 x 28¼	6′ 10½″	3,147	199	52	81	
16	Italy......	State................	2–6–2 C.	14 / 23½ x 25	6′ 0″	2,615	213	...	70	
17	Holland....	North Brabant.......	4–6–0	19 x 26	6′ 6″	1,644	200	...	57¾	
18	India.......	East Indian..........	4–6–0	19 x 26	6′ 1″	1,615	180	46¾	62½	5′ 6″ gauge.
19	France.....	P. C. M.............	4–6–0 C.S.	14½ / 21¼ x 25½	6′ 6″	1,646	227	48	66½	
20	Egypt......	State................	4–6–0	19 x 26	6′ 3″	2,321	180	51½	68½	
21	India.......	East Indian..........	4–4–2	19 x 26	6′ 6″	1,615	180	31	60¾	5′ 6″ gauge.
22	India.......	Bengal-Nagpur.......	4–4–2 C.	13 / 21½ x 26	6′ 6″	1,899	220	34½	72¼	5′ 6″ gauge.
23	Germany...	Prussian State........	4–4—2 C.	15 / 22¾ x 23⅝	6′ 6″	2,750	199	32½	73½	
24	England....	S. E. C. R......	4–4–0	19¼ x 26	6′ 6″	1,532	180	35	52½	
25	England....	G. W. R.............	4–4–0	18 x 26	6′ 8½″	1,818	200	36	54½	
26	England....	G. N. R.............	0–6–0	18 x 26	5′ 8″	1,250	170	46¾	46¾	
27	France.....	Western.............	2–6–2 C.T.	13⅜ / 20¾ x 23⅝	4′ 11″	1,926	213	49½	73½	
28	Luxembourg	Prince Henry.........	2–6–2 T.	17⅝ x 24¾	4′ 11″	1,330	170	48	67	
29	India.......	East Indian..........	0–6–4 T.	18 x 26	4′ 6″	1,256	160	49¼	68¾	5′ 6″ gauge.
30	Manchuria..	....	2–6–4 T.	19 x 26	4′ 6″	1,498	180	51	83½	
31	England....	G. C. R.............	0–8–4 T.N.	18 x 26	4′ 7″	1,911	200	74	97	

by eight-coupled engines, the usual train load being at least sixty wagons, and, in many cases, large capacity bogie wagons are used, so that the shunting engines are required to be very powerful. For that reason a special design has been introduced for work at these sidings, and one of these, designed by the locomotive superintendent of the Great Central Railway, Mr. J. G. Robinson, is illustrated. They are very large machines, weighing some ninety tons in working order, having eight coupled wheels, a large boiler with Belpaire firebox, and three high-pressure cylinders, actuating cranks 120 degrees apart, so that a regular and powerful turning effect is obtained. All three cylinders are 18 inches diameter, with a stroke of 26 inches. The outside cylinders operate the third pair of coupled wheels, the inside cylinder driving the second coupled axle. These engines have been constructed by Messrs. Beyer, Peacock & Co., Ltd., of Gorton, Manchester.

It will be obvious that many other locomotives could be referred to, and the writer has had a difficult task to make an adequate and comprehensive selection from the large number available for consideration, but the foregoing well sets forth the main features of the world's locomotive practice in 1908, and indicates that finality in locomotive design is yet a long way off.

In conclusion the writer has to acknowledge his indebtedness to railway officials and the officials of locomotive-building firms for their courtesy in supplying material for this review, necessarily not exhaustive, of "Remarkable Locomotives of 1908."

THE SUCTION GAS PRODUCER

By T. W. Burt

THE first suction gas producer was introduced into England about 1896, but it was not until about 1903 that this apparatus was seriously taken up by the British gas engine makers, and at this time a number of different designs were put on the market. These producers, which generally based their design on a certain German plant, gave very encouraging results, and since then very rapid strides have been made, most of the makers having redesigned their apparatus, in each of which some distinctive features generally appear. So marked has been the advance in this industry that there are now at least twenty-five firms in England alone making suction producers, of whom about two-thirds also construct gas engines.

It is now proposed to give a short survey of the theory of producer gas, indicating the general principles to be complied with and then show how the various makers have endeavoured to do so.

The earliest type of gas producer consisted of a firebrick-lined generator filled with red-hot fuel, through which a supply of air was blown. This produced gas practically consisting of carbon monoxide and nitrogen in the proportion of 35 per cent. and 65 per cent. by volume, respectively.

$$2\ C + O_2 = 2\ CO.$$

The working difficulties were, however, so great that this type of producer was not a success, for the temperature of combustion was so high (at least 1,200 degrees C.) that the tendency to form clinker was very great. There was a heavy amount of wear and tear with the apparatus, and the whole operation of making and using the gas showed a less heat efficiency than is obtained to-day. The next advancement was to work the producer intermittently, blowing up the fire with air and then blowing in steam, and after the temperature was lowered sufficiently the air was again injected, and so on. The steam was decomposed, as shown by the following equation:

$$C + H_2O = CO + H_2.$$

The decomposition of the steam commences between 500 degrees and 600 degrees C.; but if when working the temperature is allowed to fall to about 875 degrees C., then CO_2 begins to be formed in excess, and, as it is not advisable for this gas to contain more than 3 per cent. of CO_2, the temperature was not allowed to fall below 1,000 degrees C., after which the air was again blown in.

This method, as we can see, is not suitable for making a gas for driving gas engines, and so in 1879 Mr. E. M. Dowson invented a process by which a gas known as Dowson gas was obtained. The method consisted of blowing steam and air together into the hot fire, and the functions performed by the steam are as follows:

1. It reduces the temperature of combustion, and thereby the tendency to form clinker.

2. It enriches the gas by supplying free hydrogen.

3. It supplies additional oxygen to unite with the carbon without the attendant nitrogen, as when air is used. Nitrogen, of course, being uncombustible, dilutes the gas.

4. It enables a continuous action

to be obtained. Assuming all the carbon and oxygen to unite to form CO, then the final equation of the process is as follows:

$$3\ C + O_2\ H_2O = 3\ CO + H_2.$$

In practice, however, this is not found to be the case, as a certain amount of marsh gas, CH_4, and carbon dioxide, CO_2, are formed, and the resulting gas has the following composition:

	By Volume
Carbon dioxide	6.09%
Carbon monoxide	20.13
Nitrogen	56.24
Hydrogen	15.64
Marsh gas	1.16
Oxygen	.74

Cal. value, 139 British thermal units per cubic foot.

In spite of the heat absorbed in decomposing the steam, a large amount of heat is carried from the producer by the hot gas, which heat must be got rid of before the gas reaches the engine. In practice the gas must be cooled down to atmospheric temperature, and this is done by the scrubber, pipes, etc. It is evident that both the air and water must receive heat before entering the furnace to fit them for their work, the water converted into vapour and the air heated to increase its moisture-absorbing capacity. In the earlier producer this heat was supplied by a separate boiler, and it is at once clear that the heat lost with the outgoing gases and in heating the preliminary air and water all made for a very low efficiency. In practice it was found that the coal used in the boiler was about 25 per cent. of that used for gas-making. It easily follows that the regenerative principle must be employed, whereby the heat rejected with the gas will be transferred to the ingoing air and steam, and the more heat transferred, the higher will be the heat efficiency of the whole producer. It is, therefore, in this particular part of the apparatus that the main differences in design lie. The suction producer, by abolishing the external boiler and gas holder, marked a great step forward, and the economies obtained in the earlier plants were so marked that engineers were urged on to perfect this apparatus, and the unqualified success of the present-day suction plant is the result of their labours. To enable readers not familiar with this type of producer to understand what follows, we will explain its action.

The outlet from the cleaning scrubber is connected to the engine gas valve, which is under the direct control of the governor, and when the engine requires to take in gas the gas valve is opened and the suction of the piston reduces the pressure in the gas plant to below that of the atmosphere. At the other end of the plant is an opening to the atmosphere, and through this air is drawn, which is made to traverse a course during which it is heated and saturated with steam, afterwards being drawn up through the fire and forms the gas, which is then led to the scrubber to be cleaned, cooled and dried before going to the engine. As the governor only opens the gas valve to suit the load on the engine, it follows that gas is only made to suit the power developed and coal thereby consumed in proportion.

A fault found in the earlier producers, and afterwards used as an argument against modern ones, was their inability to work satisfactorily under varying loads. The cause of the liability to slow down when changing from a light load to a heavy one is as follows. During the time the engine is running on the light load the number of suctions on the producer are few in comparison to those at full load, and consequently the fire cools down between each suction. In addition, the temperature of the generator is not reduced as rapidly as the load, and so an excess of steam is formed which absorbs heat from the fire.

When oxygen is drawn over heated carbon combustion commences at about 400 degrees C. with the formation of carbon dioxide (CO_2) and carbon monoxide (CO), and as the

temperature increases so does the quantity of carbon dioxide, till at 500 degrees C. the maximum quantity is formed. From 500 degrees C. to 800 degrees C. the quantity of CO_2 formed begins to decrease, till from 900 degrees C. to 1,000 degrees C. only traces of this gas exist. As the quantity of CO_2 decreases, so the quantity of CO formed increases. With air, however, containing nitrogen, slightly different results are obtained, as the maximum amount of CO_2 is formed at 600 degrees C., gradually decreasing in quantity as the temperature rises, till at about 1,000 degrees C. only traces of it remain. At light loads the producer fire has so cooled down, as explained above, that, when the full load is applied suddenly, the temperature is not sufficient to decompose the steam, and the depth of incandescent fuel insufficient to reduce the CO_2 to CO, so that the gases contain too much CO_2 and steam and too little hydrogen, with the result that the quality is too far reduced for the engine to develop its full power.

If the load were gradually increased, so as to gradually increase the temperature of the furnace, then the gas consequently would get richer and richer, to suit the increasing load till the full load could be finally carried. Unfortunately, some classes of work will not allow of this, and so, to endeavour to overcome this difficulty, experiments have been made with the dimensions of the furnace and scrubbers, with the result that suction plants may now be said to be quite satisfactory on this point. When it is considered that the earlier plants would not allow of the engine running unloaded at all, and that the best plant at the Derby trials took up its full load in half a minute after running light for two hours, it can be seen what progress has been made. In addition, some makers fit devices for automatically varying the quantity of steam to suit the load, so that at light load more air and less steam are drawn in; but in very few cases are these devices found to be really necessary, and so will not be included in our description of the various plants.

As it is with the method of recovering the heat from the hot gases that the efficiency of the plant to a large extent depends, it is proposed to deal with this part of the apparatus first.

There are three methods of abstracting the heat from the gases, either by doing so before the gas leaves the generator or afterwards, or a combination of both methods. The following list gives an indication of the general practice:

First method—Tangye, Crossley, Hornsby, Rustin.

Second method—Kynoch.

Third method—Acme, National.

As an instance of the first type, we show a section on Fig. 1 of the Tangye vapourizer, which is typical of the Acme, Hornsby, Rustin and Crossley designs, and it will be observed that it consists of a cast-iron vessel open to the atmosphere and presenting a large surface to the hot gases. As is usual in this type, it is kept nearly full of water, and the air enters at the knee on the top, travels over the surface of the water, and is then led down under the fire bars. In the Tangye, Crossley and Rustin types the cold water is fed directly into the vapourizer, and no attempt is made to abstract heat from the gases after they leave the generator, except in the Hornsby plant, where the water is first led on to a tray above the gas pipe just as it leaves the producer, as shown in Fig. 2.

On the Crossley plant the vapourizer forms part of the storage bell, and projects down into the producer, and cold water is fed to the bottom of this. As the steam and air enter the bottom of the generator, they pass through two boxes fixed on the level of the fire-grate, and are thereby superheated.

Coming now to the external type

of vapourizer, we give an illustration of the Kynoch plant, from which it will be observed that all the heat for the ingoing air and steam is obtained from the downward gas pipe from the generator. A jacket surrounds the gas pipe, the outside of which latter is cast with a spiral gutter, down which the water trickles and is absorbed by the air going in the same direction. Whilst this system has the advantage of cooling the gas more, it does not generate as much steam as the first method, and there is the chance that it may not generate sufficient for the load on the engine.

It would now seem that the best results would be obtained from a combination of both methods, and in Fig. 4 we show how this is done on the Acme producers.

The water is fed into a tube inserted in the gas pipe and afterwards flows into the vapourizer proper, which is similar to that fitted to those plants working in the first method. In addition, the air passes up the outside of the pipe, whereby it is heated to about 80 degrees C., so increasing its moisture capacity, after which it passes over the water in the vapourizer and then under the fire-grate.

Owing to the different temperatures to which this part of the plant is subjected, due care must be taken in the selection of a suitable material for its construction. The smaller generators of several firms have, for a number of years, been constructed wholly of cast iron, and, in spite of prophesied fractures due to the strains set up by the expansion and contraction, appear to give satisfaction. In this size of plant, however, we find that some of those firms abandon the cast iron for wrought iron or steel plates riveted together, and we find the following:

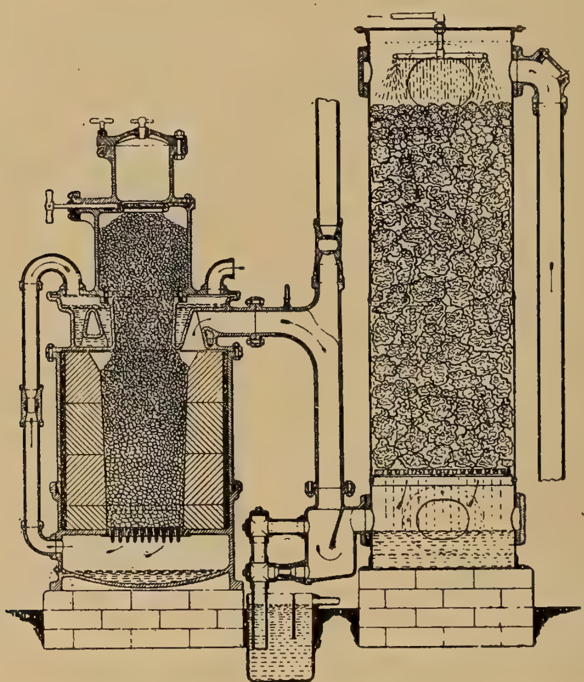


FIG. 1.—SECTIONAL ELEVATION OF THE TANGYE "SUCTION" GAS PRODUCER

Cast iron—National, Rustin.

Wrought iron—Tangye, Crossley, Kynoch, Hornsby, Acme.

The balance, therefore, lies with the wrought-iron plates; but this may only be temporary, and what the final decision will be, time alone can tell. With the fire-bricks on this size of plant about 10 inches thick, and a layer of sand interposed between them and the outside shell, it cannot be said that the temperature of this latter can be excessive; and besides, by using cast iron the whole plant can be taken more easily apart for examination.

Naturally, a prime consideration is the size of the furnace, and it would appear that, to overcome the tendency for the fire to cool down at light load a small grate area is necessary, so as to give a high velocity to the ingoing air and steam. Against this, however, there are many points to be considered to ensure satisfactory working, and thus these dimensions have been generally acquired, as explained above, by trial and error.

The furnace and fuel container must be of ample size to allow of various quantities of fuel being used and make as little stoking and clinkering necessary as possible. If the furnace is too small, then the plant cannot be run at full load without frequent cleaning, stoking, clinkering and careful attention, besides the use of only the best coal. The question of size is, therefore, of great moment, and although no two makers agree on this point, the writer has found that excellent results are obtained with a furnace 31 inches in diameter and a height of 44 inches.

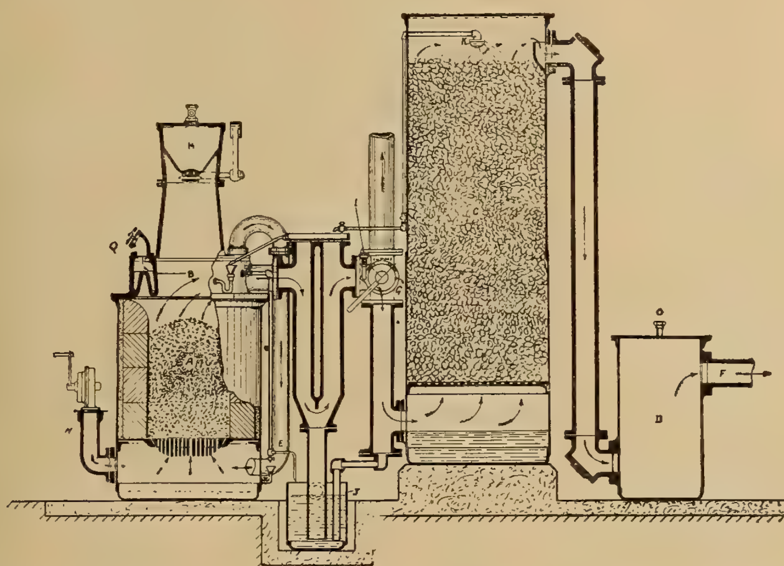


FIG. 2.—THE HORNSBY-STOCKPORT GAS PRODUCER. RICHARD HORNSBY & SONS, LTD., GRANTHAM

From experience with different sizes of plants we have found that the following dimensions are in every way satisfactory:

Brake-horse-power	Cubic Ft. Cap. of Furnace per Brake-horse-power	Cross Section of Furnace, Sq. Ft. per Brake-horse-power
10	.11	.078
20	.12	.053
30	.132	.053
40	.14	.053
50	.15	.053
70	.16	.053
100	.179	.053

As against these sizes given above, and to show how different makers'

practice varies, we find that the fire-bricks on the Tangye plant are 26 inches in diameter by 24 inches high, and with the Kynoch producer, 22½ inches in diameter by 60 inches high, with a thickness of 8 inches.

There is a general uniformity in the design and arrangement of the blowing fan, and, in all the types under consideration, the air is blown directly into the generator under the fire-bars, except in the National plant, in which the fan is bolted on to the casing surrounding the gas outlet pipe, and the air follows the same course as when the plant is working.

The fan propeller is usually about 10 inches in diameter, and the spur gearing for driving this usually reduces the speed to the turning handle in two stages, each reduction being six to one.

As the time taken to blow up the fire varies from five to ten minutes, depending on the make of the producer, it is much better that the fan should be power-driven, thus enabling the attendant to get the engine ready for starting during this operation, and so reduce the starting time by half. This can either be done by an electric motor of about ½ horse-power driving the fan by a belt or

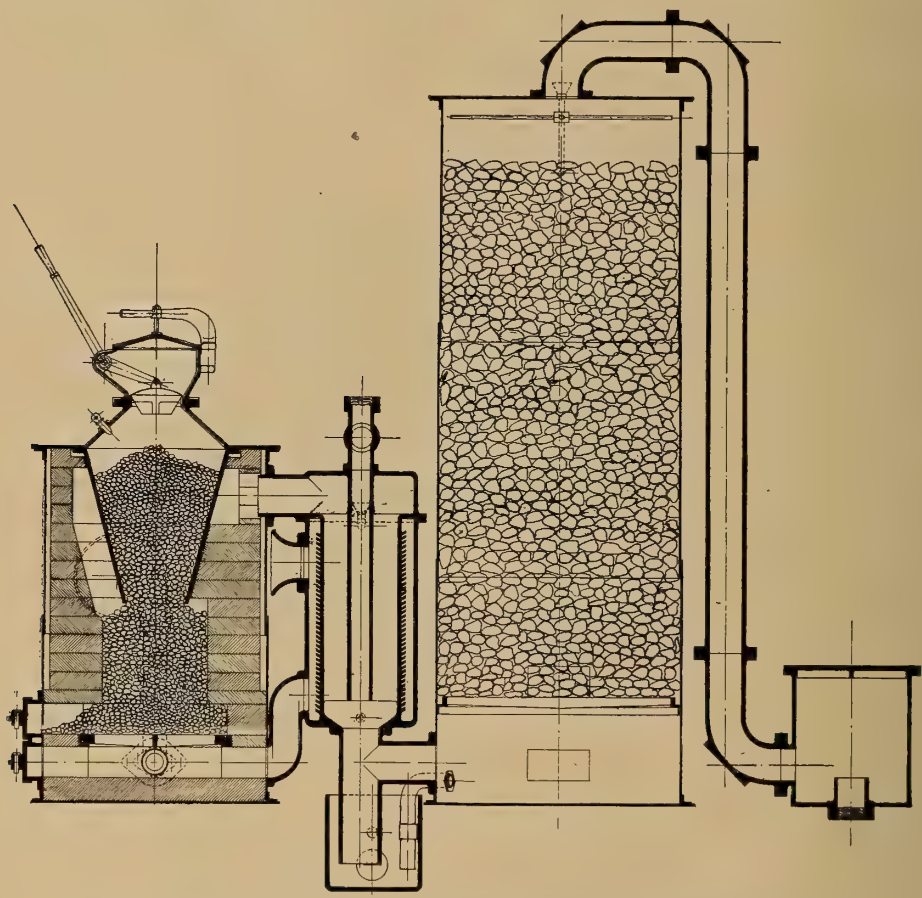


FIG. 3.—VERTICAL SECTION OF THE PRODUCER MADE BY THE KYNOCH COMPANY, BIRMINGHAM

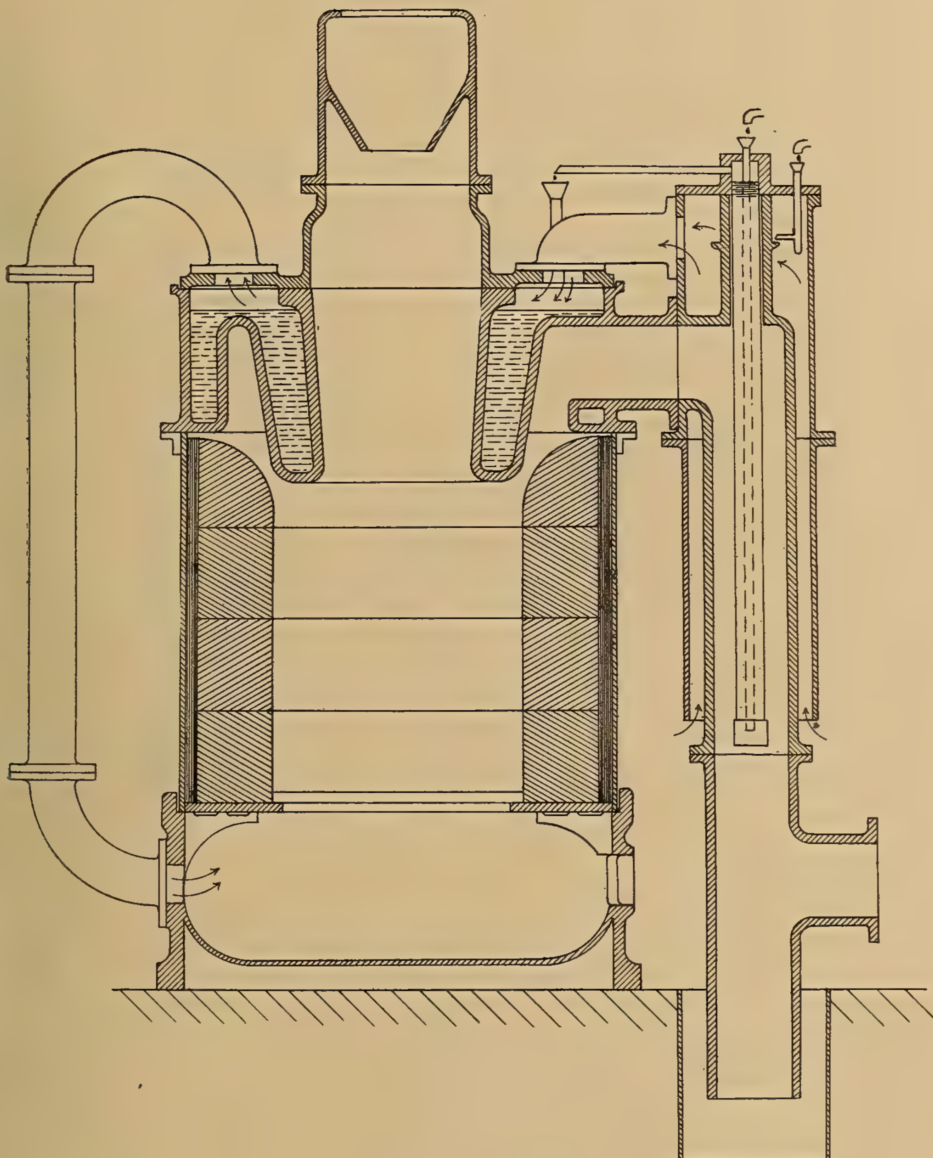


FIG. 4.—ACME GAS PRODUCER

by a small Pelton wheel using water from the main. Both these cost very little to operate, are cheaply installed, avoid the reducing gear, and are of great service in working the plant.

Generally the overflow water from the vapourizer is led into the bottom of the generator, thence overflowing into the seal pot. The presence of this water helps to augment the steam supply, and, in addition, when the ash doors are opened for poking and clinkering the fire, the ashes fall into the water and generate steam, which takes the place of the ordinary supply now cut off on account of the air

being drawn on direct through these doors instead of over the vapourizer. This is a very necessary arrangement and enables the fire-doors to be kept open longer without affecting the quality of the gas to any great extent. In some dry-bottom producers arrangements are made for temporary running water into the fire during poking and clinkering, which serves the same purpose. The Crossley, National and Kynoch plants have a dry bottom, but without this extra fitting.

As the gas leaves the generator, the pipe turns downwards and dips under water contained in a small tank called the water seal or seal pot. It is made in some plants of cast iron and in others of wrought-iron plates, and it is from here that all the waste water runs off to the drain. By arranging the gas pipe with an open end under the water the plant is provided with a safety valve, and if by chance any explosion takes place, the pressure escapes here and prevents any damage being done. As part of the sulphide contained in the coal appear in the gas as sulphuretted hydrogen and sulphur dioxide, both of which are soluble in water, the waste water is apt to cause a smell, and for this reason it is better to provide this tank with a lid, but in very few cases is this done. In the Tangye plant the tank is of cast iron and is divided into two compartments, the dividing web extending from the top to within an inch or two of the bottom. The gas pipe dips into one division and the overflow leaves at the other one, so that any scum and suspended matter is prevented from going down the drain and can be extracted periodically.

Immediately above the seal pot a right-angled branch takes the gas into the bottom of the scrubber. In the Acme plant the end of this pipe dips under the surface of the water, and this tends to deposit the tar. In addition, it acts as a cock, and keeps the scrubber and pipes automatically full of gas after the engine is stopped, which gas is used for starting. In the Tangye, Hornsby, Rustin and Kynoch plants, the gas is not made to bubble through the water, and a cock has to be closed to keep these parts full of gas when the engine is standing.

The Tangye producer has two overflow pipes from the scrubber, and in closing the bottom one the water rises to the level of the top one, at the same time immersing the gas inlet pipe, and so prevents any escape. All the scrubbers have an overflow pipe for taking the cleaning water into the seal pot. The capacity of the scrubber should be such that only one changing of coke is necessary per annum, and a general uniformity of size is found, namely, 3 feet in diameter by 12 feet 13 inches high. The material used is wrought-iron plates ¼ inch thick, with a tray about 2 feet from the bottom for carrying the coke, which should not be in smaller pieces than 3 inches cube, with still larger pieces at the bottom. Foundry coke is best suited for this purpose, as it is more porous and less brittle than gas works coke. In some quarters a cast-iron bottom is advocated, so as to better resist the corrosive action of the water; but this arrangement has not yet become general. In the Crossley plant two scrubbers were originally used, but these are now replaced by one, the bottom part containing coke and the top part sawdust, cane shavings, etc., or any such material, for further cleaning and drying the gas.

Situated close to the engine is the expansion box, which is of great service to the engine in starting and working under varying loads. The larger it is, the better the results obtained, that on the Tangye plant being about 2 feet in diameter by 5 feet long, that on the Acme plant 2 feet 6 inches in diameter by 3 feet 6 inches long, while the National one is still smaller and made of cast iron.

To enable the producer to work successfully with varying qualities of fuel, and to deal with the additional

amount of tar and impurities found in the gases given off by the poorer anthracites and gas works coke, a purifier is often substituted for the expansion box. This is a wrought-iron tank, generally made cylindrical in shape, and containing a number of shelves over which is spread sawdust, wood shavings, cane shavings, wood wool, or any such substance capable of arresting any impurities in the gas. In a plant of this size, particularly one running for long periods without stopping, it is better to fit this apparatus, even when using Welsh anthracite, as it lengthens the time the valves, piston and pipes will work without cleaning. In the Tangye plant what is termed a tar-catcher is fixed at the inlet to the expansion box. This is a cast-iron box containing a number of plates, which make the gas take a zig-zag course, and the tar condenses on the surfaces of the plates against which it strikes.

As mentioned above, the gas pipe is made 7 inches in diameter, and, as tar and dust are constantly depositing on the walls, it is necessary that easy means of access are provided for cleaning. In some plants the pipes have to be entirely disconnected, but in the majority all the bends are provided with doors, which, on removal, admit of a wire brush being inserted. The advantage of having these fitted is obvious. Again, it should be particularly noted that drain cocks are necessary at various points, for, when absent, cases have occurred in which much trouble was caused by the condensed water obstructing the passage of the gas to the engine, thus preventing it developing full power, and, in some cases, preventing it working at all.

When the water supply is uncertain and apt to vary in pressure, a tank should be erected above the scrubber fitted with a ball cock valve, and so a constant supply will be available at all times.

To make the triumph of the suction plant complete now only requires its ability to digest bituminous coals, but unfortunately at present this cannot be realized. The excessive amount of tar formed with the gas from this fuel renders its use prohibitive in ordinary standard plants; but many minds are at work on the problem, and before long we may expect to see the successful commercial bituminous suction plant on the market. With the ever-increasing price of anthracite, the necessity for this new producer becomes more and more evident; but at present we must content ourselves with the fuels at our command, of which anthracite is most universally used. The best anthracite is found in Wales; but the cost of working it keeps the price very high as compared, say, with that found in Scotland, which, however, is of poorer quality. The three essential features to be considered when selecting a coal are first, size; second, percentage of ash; third, percentage of volatile matter.

The smaller the pieces of coal are with which the producer will work the cheaper the price per ton will be, and it is in this respect that some plants have advantages over others. Producers of this size ought to be able to use coal varying from ⅜ to 1 inch cube; but, as this size usually contains an excessive quantity of dust, it is advisable either to purchase it washed or riddle it before use. This dust, it should be noted, contains many impurities, and is very liable to choke the fire, with the result that bad gas is formed, owing to the steam and air not passing through it evenly. In addition, a quantity of the dust falls unburnt through the fire-bars, and so it is seen that, while the full price of the coal is paid for the dust, it is practically valueless for gas-making and often injurious to the successful working of the producer.

The best Welsh anthracite contains from 2 to 3 per cent. of ash, but it is quite permissible to use a coal containing as much as 6 or 7 per cent.; but above this special attention must be paid to dealing with the clinker.

It is not only the quantity of the ash, but also its composition, which concerns us, particularly the amount of oxides of iron, etc., present in relation to the amount of silica. At the high temperatures prevalent in a gas producer these oxides combine with the silica in the ash and fire-brick lining and form silicates, which are more or less fusible, according to their composition. The silicate of iron, for instance, fuses at a comparatively low temperature, forming the clinker, which adheres tenaciously to the walls of the generator.

Red ash fuels are generally fusible, as they contain iron.

The excessive quantity of volatile matter in bituminous coal is why it is at present useless for suction plants, this being as much as 40 per cent. of the whole, whereas that in anthracite varies from 4 to 10 per cent. Generally speaking, increase of volatile matter increases the likelihood of the gas being charged with tar, and no coal containing more than 10 per cent. should be used unless special means are adopted for collecting the tar.

It is thus evident that, price being equal, preference should be given for that coal which contains least dust, volatile matter and ash. A little can be allowed, however, if price is a consideration, as in the case of Scotch anthracite, which is much cheaper than Welsh, but contains more volatile matter and ash. The advantage of having the generator amply big for its output is here exemplified, whereby we may use various grades of inferior coal without trouble. We give examples of three grades of coal, so that readers may have a standard from which to work:

	Scotch Ant., Per Cent.	Welsh Ant., Per Cent.	Bit. Coal, Per Cent.
Fixed carbon...	80.19	91.0	53.5
Volatile matter..	10.03	4.5	40.0
Sulphur	.71	.5	.5
Ash	3.85	2.0	5.0
Moisture	5.22	2.0	1.0

Coalite has lately been mentioned as a fuel for suction plants, and is quite satisfactory, both from practical results and from consideration by analysis. As soon as the price is reduced it will become a serious rival to anthracite and coke.

COALITE	Per Cent.
Fixed carbon	81.0
Volatile matter	6.0
Sulphur	.5
Ash	8.70
Moisture	3.8

At the present time, with anthracite so dear, a substitute is found in gas works coke, which gives very good results. It should be noted that the quantity of gas given off is less than that from an equal weight of anthracite, thereby necessitating a slightly larger generator. If, however, as is advocated above, it is amply large for anthracite, then it will be found capable of meeting all the demands made upon it by the coke. Anthracite of 14,000 B. T. U's per pound gives approximately 90 cubic feet of gas, 135 B. T. U. Coke of 12,500 B. T. U.'s per pound gives approximately 74 cubic feet of gas, 137 B. T. U. The consumption of coke will, therefore, be about one-fourth more than anthracite.

The coke should be in pieces of from ½ inch to 1¼ inches cube, well carbonized and washed, otherwise dust and tar will be found in the gas.

Foundry coke is unsuited, principally on account of the excessive quantity of sulphides it contains, which are carried along with the gas and are liable to form sulphuric acid with the steam, which acid corrodes the cylinder, etc. Sulphuretted hydrogen is also formed, and this gas readily attacks copper, so that all fittings containing this metal should not be brought in contact with the gas.

A question very often raised is that of repairs and maintenance, and, from many years' experience of different plants, we may state that this will not exceed £4 per annum. This comprises a new set of fire-bricks and coke for the scrubber, together with the renewal of joints, etc., broken to effect these repairs.

While practical working results of suction gas installations are now quite common in the smaller sizes, difficulty is experienced in obtaining these for the larger sizes, owing principally to the plants not being long enough installed to warrant the publication of data. From tests and other observations we can, however, estimate what an engine of this size will cost to run, which estimate we can consider as fairly reliable, judging from our experience of smaller plants.

We will base our estimate on the assumption that our engine is running at its maximum working load of 100 brake-horse-power, so that, for this size of engine, our total costs cannot be higher, but will decrease if the engine is working at less than the above power. Interest on capital, depreciation, etc., we will exclude, as they vary for each individual case and can be added to suit.

The coal consumption is guaranteed by most makers as 0.57-0.8 pounds per brake-horse-power-hour under test, but this must on no account be confused with the actual consumption under working conditions. During meal hours and overnight when the engine is standing coal is being consumed to keep in the fire, and some is also drawn out with the ashes and thrown away. From careful tests extending over many days, it has been found that these standing losses bring up the consumption to about 1 pound per brake-horse-power-hour at loads varying from three-fourths to full load. Assuming an engine to work 53 hours per week, the consumption will be $53 \times 100 \times 1 =$ 5,300 pounds per week, which, with coal at 15/- per ton = 35/6.

At the Derby trials the winning plant used 1 gallon of water per brake-horse-power-hour for cleaning and cooling the gas, as well as supplying the steam, and it was thought in some quarters that too little was being used, the detrimental effects not being evident on such a short trial. From other independent tests, however, we find that this amount of water is sufficient, and so our plant will use 5,300 gallons per week, which, at 4*d*. per 1,000 gallons, costs about 2/-. Of course, with a plant wherein no attempt is made to recover the heat from the gas for steam-raising, it will enter the scrubber hotter, and so require more water to cool it; but this increase will not add much to the total costs.

The quantity of oil consumed is dependent on the lubricating details, and, assuming the engine has ring lubrication of the main bearings, 3 gallons of oil per week should suffice, which, at 1/9 per gallon, costs 5/3.

Provided the generator is big enough for its duties, so as to avoid the necessity for continual clinkering, poking and stoking, then, exclusive of starting and stopping, all the attention required is from five to ten minutes every two or three hours, and so an ample allowance of 18 hours per week will cover everything, including cleaning the engine and producer. At 6*d*. per hour, this comes to 9/- per week.

TOTAL COSTS PER 100 H.P. PER WEEK

Coal	35/6
Oil	5/3
Water	2/-
Attendance	9/-
	51/9 = .117 per brake-horse-power hour.

Unlike the gas engine, which has more or less reached a standard basis, the producers of the various makers are constantly being altered and revised, as practical experience suggests.

At present, therefore, it is impossible to foretell the ultimate finality in design, and even when this is reached the advent of the bituminous plant will have created a new set of conditions, for the anthracite plant can only at the best be considered as a stepping stone to the ultimate universal adoption of the bituminous suction plant. When this is achieved then nothing can prevent the almost total suppression of the reciprocating steam engine, both on land and sea.

SWEDISH HYDRO-ELECTRIC POWER PLANTS

II.

By John Geo. Leigh

THE power station now in course of erection for the Swedish State at the Trollhätte falls, and expected to be completed during the current year, will be one of the most important, and eventually, in all probability, the largest of European hydro-electric installations.

There are five falls at Trollhättan, the Nol and Toppö falls, each about 31 feet in height; the Gullö and Hell falls, each about 28 feet, and the Stampeström fall, with a head of 17 feet. The banks of the Göta River in their vicinity are steep and rocky and often of considerable height, and the scenery is picturesque and attractive in the extreme.

Smaller, but important, waterfalls in the Göta River are the Vargö (Wolf's Island) falls, near Lake Vennern, and the rapids of Lilla Edet, below Trollhättan. These prior to 1908 belonged to riparian owners, who utilized part of their energy for industrial purposes, particularly in connection with neighbouring wood-pulp and paper mills. Now, however, by ruling of the Swedish courts, or by purchase, duly ratified by the Riksdag, the State is sole owner of almost all the water-power of the Göta River.

The difference in elevation between Lake Vennern and the sea at Gothenburg is about 138 feet. The present minimum discharge of the lake is about 11,300 cubic feet per second, and the maximum flood discharge about 31,785 cubic feet per second. By storing the water in the lake there will be available not less than 200,000 horse-power, and this in a district well provided with transportation facilities and not far from Gothenburg, the most important trading city in the country and the centre of a large population.

The hydraulic arrangements at Trollhättan have been the subject of long and careful study, not only in relation to the power station itself, but also (1) to the proposed regulation of Lake Vennern, by which the capacity of the generating plant can be greatly increased, and (2) to the projected enlargement and partial re-location of the Göta-Trollhättan Ship Canal, an important highway between the Cattegat and Baltic Sea.

Prominent among the hydraulic works will be a regulating dam across the river above Gullön Island. This will have three sluices, each 66 feet wide, and one, nearest Malgön Island, only 10 feet wide, all 117 feet at the sill above mean sea-level and about 8 feet beneath the present low-water level of the river above Trollhättan. The two central sluices will be fitted with rolling dams, or strong cylinders of plate iron, 18 feet in diameter, to each of which is attached a longitudinal projection, forming, when the cylinder is in its lowest position, a watertight joint against the bottom. The cylinders are rolled up on racks of cast iron, inserted in masonry piers, and their tops, when the outlets are closed, will be about 2 feet above the low-water level of the river. The western and eastern outlets will be closed by slide-gates, supported by masonry piers and vertical steel beams. All the movable parts of the dam can be operated either by electric motors or by hand.

The design has been chosen after due consideration of the fact that

during the winter large quantities of surface ice, often of great dimensions, pass down the river. When this occurs the two rolling dams can in five minutes be completely raised, giving the ice a free passage exceeding 130 feet in width. When, however, the accumulation of ice is less severe, or when frazil ice only requires to be sluiced, it will probably suffice to raise slightly the rolling dams or open the slide-gates. These latter are designed in two parts, one above the other, sliding in different grooves. By pushing down the upper gate behind the lower one, the ice may be sluiced with a minimum loss of water.

It is believed that with these various outlets it will be possible, without raising the level of the river, to dispose of the maximum volume of 35,315 cubic feet per second which may have to be provided for after the regulation of Lake Vennern.

The head works of the intake canal have five sluices—provision being made for a sixth when more than 8,830 cubic feet per second is required for power generation—each 39.3 feet wide, separated by masonry piers. In front is placed a floating wooden ice deflector provided with a vertical leaf which reaches about 3 feet below the water surface. On the masonry piers is a foot-bridge, which supports the upper ends of vertical steel beams. The lower ends of these are fastened in the weir masonry, and the openings between them can, when necessary for inspection or repairs, be closed by wooden slide-gates. The velocity of the water at the mouth of the intake is about 8.2 feet per second, and when the sixth sluice is opened there will be provision for a flow of 12,360 cubic feet per second, this being the anticipated continuous minimum discharge of the river after the regulation of Lake Vennern.

Should, however, this estimate be falsified and further water be required, opportunity occurs for the construction of an additional intake between the conduit and the present ship canal. For connection between the main and supplementary channels provision will be made in the neighbourhood of the distributing basin, where the velocity of the water will be checked before admission to the inlets to the power station.

The canal, 4,265 feet in length, is blasted in the rock. Near the headworks and at the point of juncture with the branch canal will be placed Stoney sluice-gates, 55.7 feet wide, 29 feet high, and weighing about 65 tons. The cross-section of the canal varies considerably. As a rule, the bottom is 46 feet wide and the depth from low-water level 25 feet; but where the available space is limited and the ground very high the bottom width is decreased to 35 feet and the depth of water increased to 33 feet. Between these cross-sections are long channels designed to moderate the running water, the velocity of which at low-water level is 7.2 feet per second. The side slopes are 1 in 10. At the bottom where the canal is deepest is a gate, 17 × 17 square feet, which can be closed by a hand-winch on the masonry wall.

At the lower end of the canal for a distance of 115 feet the sides are smooth and vertical, lined with clinkers under the water surface and with hewn granite along the water-line. In this part of the channel measurements of the water discharge will be made when the turbines are tested. This will be done by means of a vertical leaf, made of impregnated sail-cloth stretched on a wooden or iron frame, which, supported by wheels running along the canal sides, closely fills the cross-section and moves with exactly the same speed as the water. This method of water-measurement is the invention of Mr. E. Andersson, a Stockholm engineer, and is stated to have given extremely accurate results.

The side walls of the canal are constructed of ashlar masonry or concrete. The latter is made watertight by a lining of rich cement grout; and

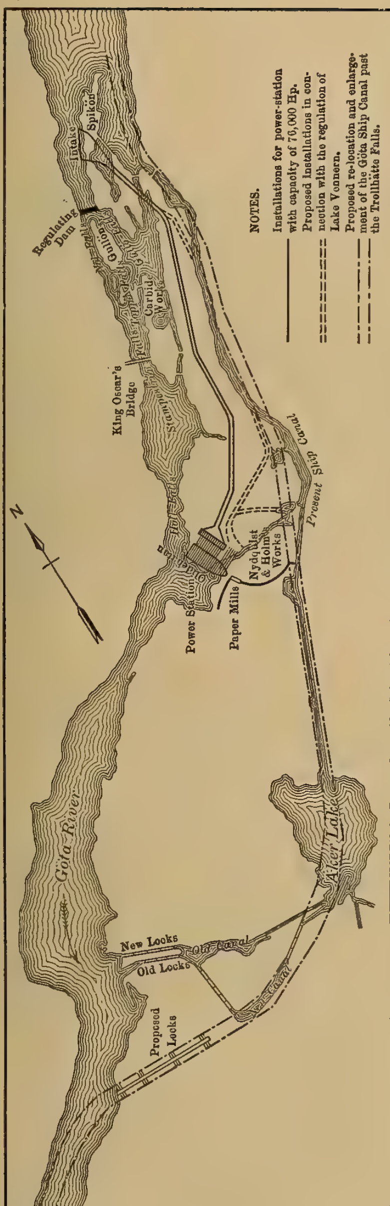
where the walls are very high iron plates, 1.18 inches thick, are with this grout fastened in the rock at the base of the wall. The plaster of cement grout is protected from the effects of the running water by a wearing course, 1.6 feet thick, consisting of granite ashlar masonry. The concrete walls are provided with expansion joints at intervals of about 32 feet, and are drained by 2-inch drain-tiles placed near the water side at a distance of about 1.6 feet, centre to centre.

ONE OF THE TROLLHÄTTE FALLS. SITE OF THE HYDRO-ELECTRIC GENERATING STATION

At the distributing basin are waste-ways, 236 feet long, capable of discharging all the water flowing through the canal should, through an accident, the total flow of water through the turbines be suddenly cut off by the governors. At each end also are arranged ice sluices. Each tube feeds a separate turbine and has its own intake chamber, containing gates and ice-screens, supported by concrete piers. The gates have a span of 26 feet, and are sustained not only by the grooves in the concrete piers, but also by two intermediate steel supports. They are operated by electric motors, and can be closed very quickly should any fault in the turbine render this necessary. The velocity of the water through the ice-screens is about 2.5 feet per second.

From the intake chambers the water is conveyed to the power station through eight large and three smaller steel tubes. The larger ones, 14 feet in diameter, feed the turbo-generators, and the smaller, 4 feet in diameter, the exciter turbines. These tubes, each about 196 feet long, are placed in tunnels blasted in the rock and lined with concrete.

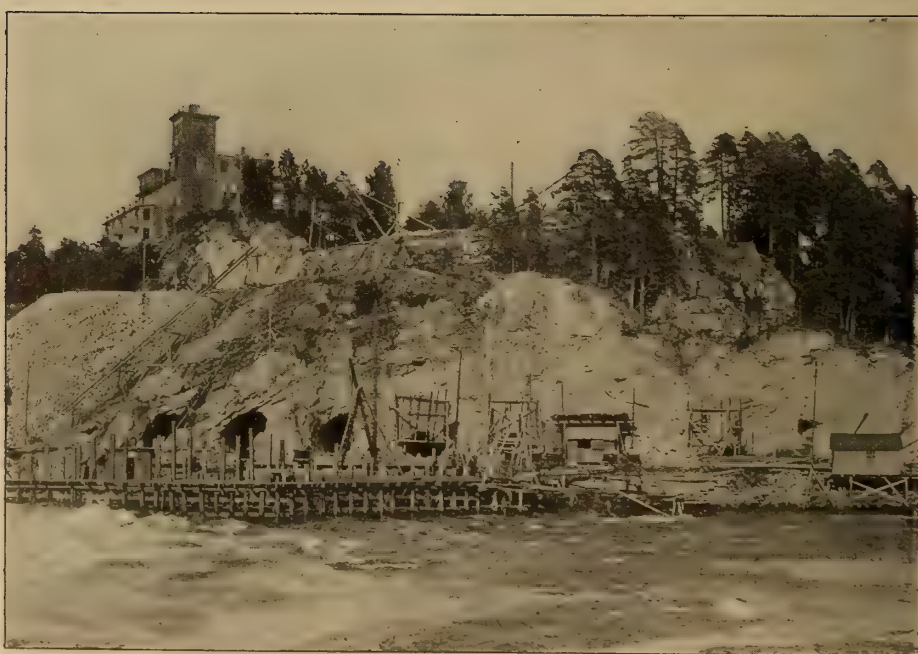
The power station includes two buildings, one for the turbines and generators and auxiliary machinery employed in converting the water power into electric energy, the other for the transformers and other appliances necessary for conveying the energy to the distributing cables. The turbines and generators will be placed on the same horizontal shafts,



TROLLHÄTTE WATERFALLS, ELECTRIC POWER STATION AND GÖTA CANAL

THE STATE POWER STATION AT TROLLHÄTTAN. SITE OF THE REGULATING DAM AND HEAD WORKS OF THE INTAKE CANAL, AUG. 8, 1908

THE TROLLHÄTTE POWER STATION. THE CANAL DURING CONSTRUCTION, JULY 4, 1908



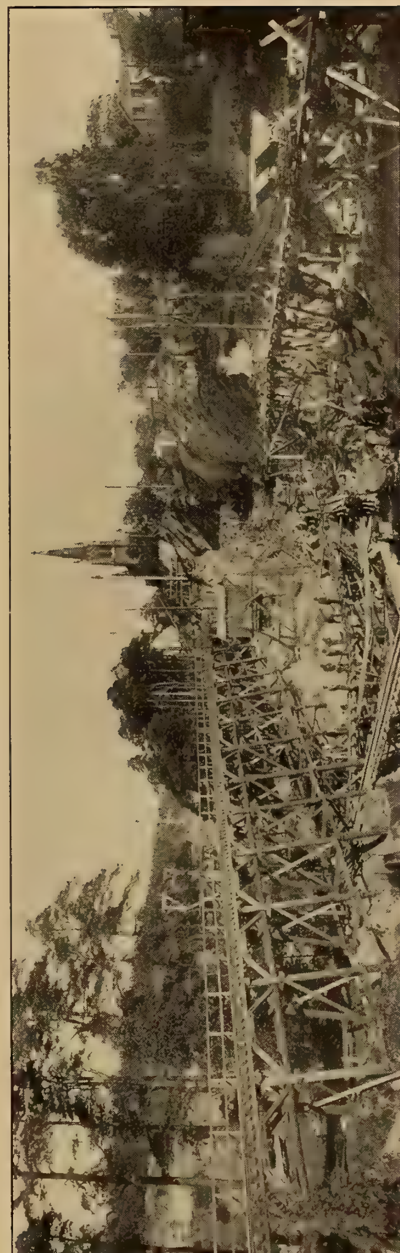
THE POWER STATION AT TROLLHÄTTAN DURING CONSTRUCTION, JULY 15, 1908

requiring only ordinary bearings with water-cooling. Each of the eight turbo-generators will, under normal conditions, develop 10,000 H. P.; but under maximum load have a capacity of 12,500 H. P. Each turbine has two runners enclosed in a steel flume; and the two bearings of the turbine shaft, which are inside this flume, are made accessible by vertical wells, even when the turbine is running. The speed of the shaft is 187.5 revolutions per minute. Each turbine has a separate governor, operated by oil at a working pressure of 15 to 20 atmospheres.

The generators will develop three-phase alternating current with a frequency of 25 cycles and 10,000 volts. They will be completely enclosed in cast-iron shells in order to ensure effective cooling and prevent any fanning of the air. Cold air will be supplied to them by closed air conduits passing through the walls of the station and under the flooring, while the heated air thrown off from the generators through closed conduits will in winter be used for heating the intake chambers and other buildings.

From the power station the electric energy will be conveyed by cables through a tunnel, 660 feet long, to the instrument and transformer building. A portion will be reserved for use in connection with the proposed electrification of State railroads, but with this exception the total output will be available for disposal to municipalities and private consumers. Half, it is expected, will be distributed at 10,000 volts in Trollhättan and places within a radius of six miles, the remainder being transformed up to 50,000 volts before transmission to more distant localities, where, at receiving sub-stations, it will be again transformed by the State and delivered at suitable tensions. The high-tension cables will be carried on iron poles bedded in concrete foundations.

The contracts for practically the entire equipment of the power station stipulated for machinery of Swedish make. The generators and the greater portion of the electric plant will be supplied by the General Electric Manufacturing Company of Sweden; and of the four turbines now to be installed two are by Nydquist & Holm, of Trollhättan, and two by the Karlstad's



THE TROLLHÄTTE POWER STATION. THE CANAL DURING CONSTRUCTION, JULY 4, 1908

Mechanical Works, of Kristinehamm.

It is an interesting fact, thus shown, that the development of the hydraulic power of the country serves not only to create new sources of mechanical power, but also to provide work for the manufacturing establishments of the nation and occupation for its inhabitants.

The total estimated cost of the undertaking, including plant of the value of £261,000, is £628,000, which works out at £10 5*s*. 6*d*. per kilowatt at 10,000 voltage, £12 10*s*. per kilowatt at 50,000 voltage, or, per electric horse-power, £7 11*s*. and £9 4*s*. 6*d*., respectively. This very moderate capital cost, combined with facts that the State can obtain money at a low rate of interest and be content with small returns, has already resulted in the conclusion of contracts for the disposal of energy on remarkably reasonable terms. In the case of the municipality of Gothenburg, the energy, after being transmitted 44 miles, will be delivered at the city limits as three-phase current of 6,000 volts. For the first 7,000 kilowatts there will be paid a fixed yearly price of about 15*s*. per kilowatt maximum demand—i. e., the average of the four highest weekly readings of the year — plus a fraction of ¼*d*. per kilowatt-hour. To obtain these terms, however, the connections have to be made within one year from the commencement of supply.

For the new and extensive electricity works of the city of Gothenburg the General Electric Manufacturing Company of Sweden has recently made considerable deliveries. These works have been planned to utilize power from the State station at Trollhättan, distributing it at a pressure of 6,000 volts, as received, to large consumers and to two substations in the city for conversion to continuous current.

To the many distinctions credited to the Joint Stock Company of Stora Kopparberg I can, I believe, add two not hitherto claimed for it. Founded in or about the year 1225 to work the great copper, gold and silver mine at Falon, it is probably the oldest industrial corporation now existing in the world. It possesses at Domnarfvet the largest iron and steel works in Scandinavia, and perhaps in the world, based on charcoal as a fuel. Its mines are numbered by the score, and the forests owned by it, and from which it derives material for its wood products, have an area not far short of a million acres. Among its sawmills may be mentioned Skutskär, Korsä, Abacka and Domnarfvet, the first, to which is

WATERFALLS AND POWER STATIONS OF THE DAL RIVER

also attached an important wood-pulp factory, being the largest in Europe; and like pre-eminence attaches, in its class, to the combined paper and pulp-mills at Kvarnsveden. To these distinctions it may be possible to add that the Stora Kopparberg Company is, after the State and of industrial corporations, the most considerable owner of waterfalls in Sweden, and, following the larger municipalities, the greatest consumer of electric energy.

All the more important waterfalls belonging to the corporation are formed by the river Dal, or, more correctly speaking, the two rivers known by that name — the East and West Dal—the former passing through Lake Siljan, below which the two streams meet. As the West Dal is not connected with any considerable feed lakes, its water supply is comparatively irregular, the minimum discharge being about 1,060 cubic feet per second and its mean industrial power about 1,765 cubic feet per second. After the confluence of the two rivers, however, these figures are raised respectively to 2,825 and 6,180 cubic feet per second; and it is estimated that, by regulating the level of Lake Siljan, the industrial water amount might be readily increased by 50 per cent.

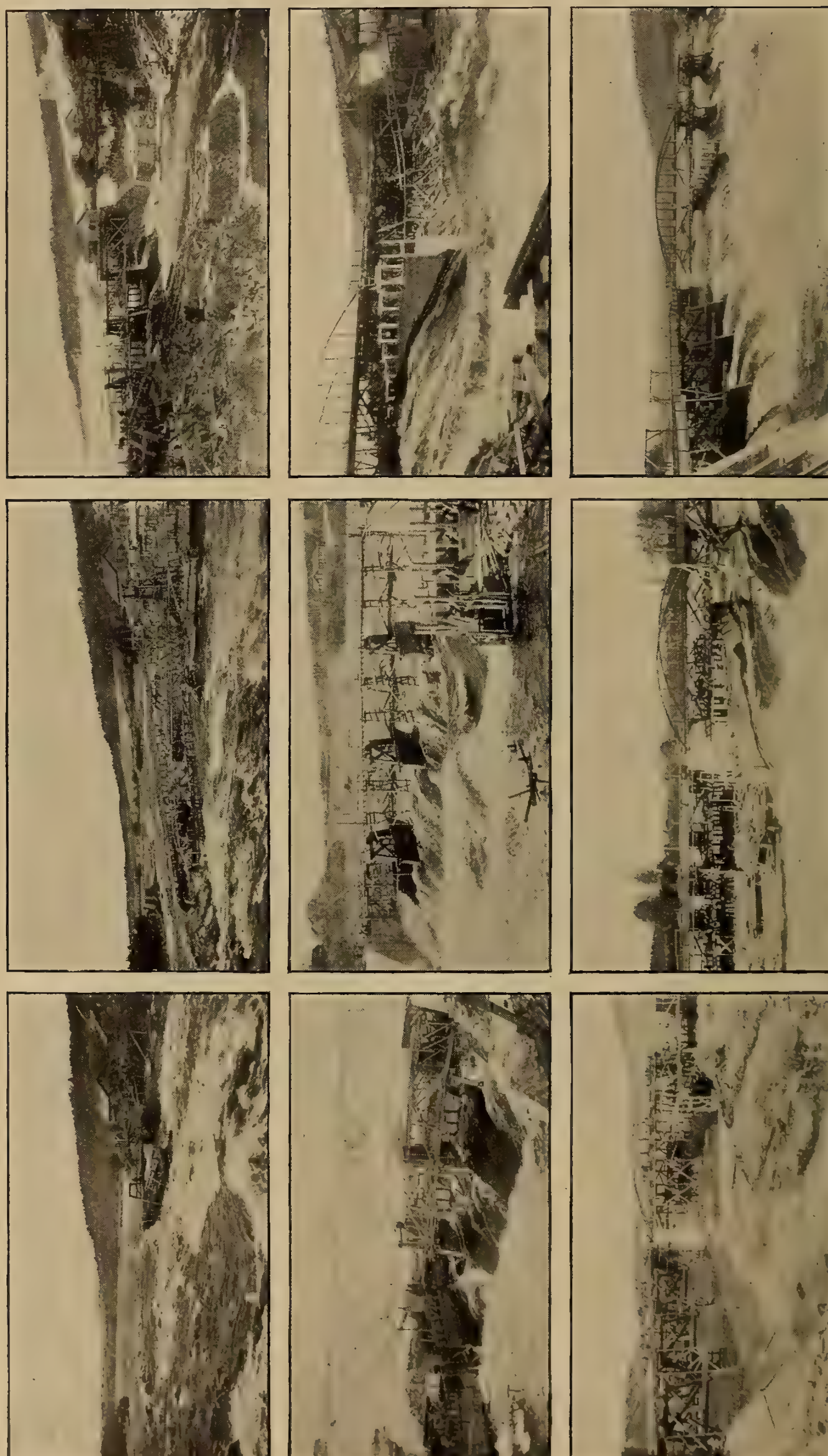
In the accompanying map the larger waterfalls owned by the Stora Kopparbergs Company are indicated by figures:

No.	Name of Falls	Head, Feet	Part Owned by Company
1.	Stop	75.4	Half.
2.	Grada	32.8	Whole.
3.	Forsbufvud	32.8	"
4.	Kvarnsveden	42.6	"
5.	Bullerforsen	36.0	"
6.	Domnarfvet	19.6	"
7.	Gustaf	32.8	"
8.	Forssa	32.8	Half.
9.	Gysinge	15.0	Whole.
10.	Söderfors	13.1	"
11.	Elfkarleö	29.5	"
12.	Elfkarleby	59.0	Seventh.

THE KVARNSVEDEN TURBINE, IN COURSE OF CONSTRUCTION

Of these falls, Domnarfvet and Kvarnsveden are fully and Gysinge and Soderfors partially utilized. Those at Stopfors and Bullerfors are now being "harnessed."

To the power stations and great dams across the river at Domnarfvet and Kvarnsveden I propose to refer but very briefly, for they have been



SERIES OF VIEWS SHOWING THE METHOD AND PROGRESS OF CONSTRUCTION OF THE KVARNSVEDEN DAM

in existence several years, have often been described, and are consequently doubtless familiar to many readers. Of the two installations, that at Kvarnsveden is the more modern, larger and more interesting. The dam, built in a broken line across the river, is 705 feet long, made up of three sections—the turbine dam, a steel and concrete construction, 213 feet long and 33 feet high; an intermediate dam, 164 feet long, built of concrete, and provided with revolving gates; and a length of 328 feet, built of stone-filled wooden caissions, fastened to the rock. In the turbine dam are sixteen chambers, each containing a double turbine, built by the Dayton Globe Ironworks, at Dayton, Ohio, and developing 1,125 H. P. at 215 revolutions per minute.

The photographs reproduced on page 144 show various stages in the construction of the Kvarnsveden dam. The caissons were built up in steps, the water being allowed free passage over them until, first on one side of the river and then on the other, they reached the required height above the surface. In the view of the dam (page 146) will be observed the canal, 685 feet long, blasted in the rock, and separated from the river channel by a stone fill, and in the background the power station and pulp-mill.

The generators, driven direct from the turbine shafts, develop three-phase current of 7,000 volts and 60 periods, and were built partly by the Maschinenfabrik Oerlikon, of Zurich, and partly by Swedish firms. With the exception of about 4,000 H. P., transmitted to the Domnarfvet Works, all the power is used by theKvarnsveden paper and pulp-mills.

GENERAL VIEW OF THE KVARNSVEDEN DAM. UNDER THE BRIDGE ON THE RIGHT IS SHOWN THE FREE PASSAGE FOR FLOATING TIMBER

The power station at Bullerforsen, now in course of construction, is expected to be completed this year. The installation is particularly interesting on account of the peculiar construction of the dam across the river. The structure, of which a plan and section appear on page 147, is built entirely of concrete, and consists of sixteen piers joined together by arches, forming the crest over which the water passes. This arrangement has been found conducive to considerable economies, to a noteworthy reduction in the amount of building material used, and—because of the

large base area of the columns—much additional stability.

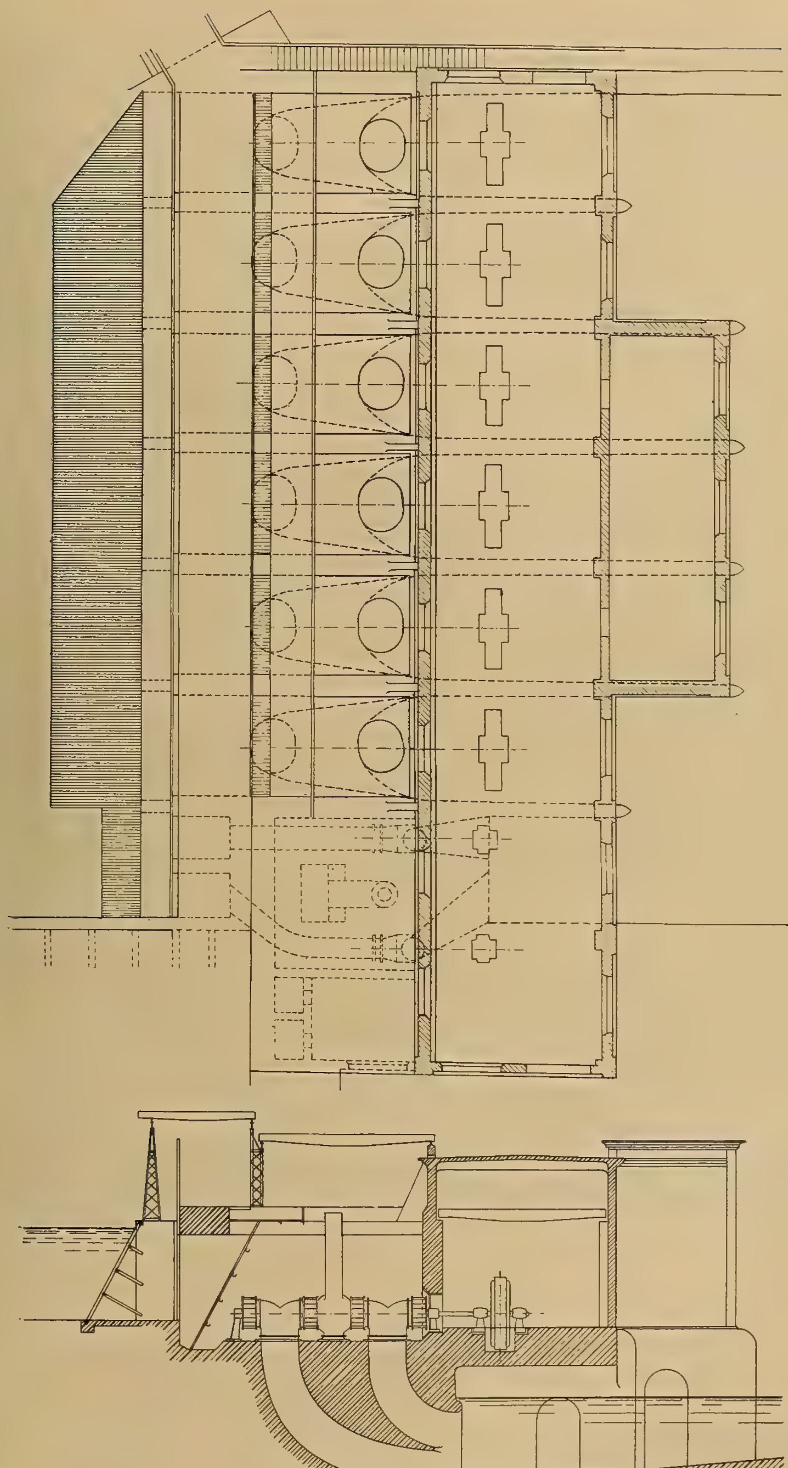
The total length of the dam is 575 feet, the sluices giving an aggregate free opening of 400 feet, with a height above sill under the normal water level of 9 feet for a distance of 230 feet and 12.5 feet for the remaining 170 feet. There are also provided an opening for floating timber, 85.5 feet long and 5.5 feet in height above the sill; an ice inlet, 20 feet wide and 12 feet deep, and a salmon sluice, 15 feet wide and 7 feet to the sill. The turbine dam is 197 feet long, and contains six chambers, each 46 feet × 23 feet, to accommodate two double turbines of 4,000 H. P. capacity. These have been manufactured in Sweden by the Karlstad's Mechanical Works, of Kristinehamm, and designed for 1,080 cubic feet per second each chamber, a minimum head of 34 feet, and 180 revolutions per minute.

The power house is built together with the turbine dam, and will be equipped by the General Electric Manufacturing Company of Sweden for three-phase, alternating current of 7,000 volts and 60 periods. It is intended to transmit all the energy developed at this station to the Domnarfvet Steel Works, for use partly for driving motors and partly for electric smelting.

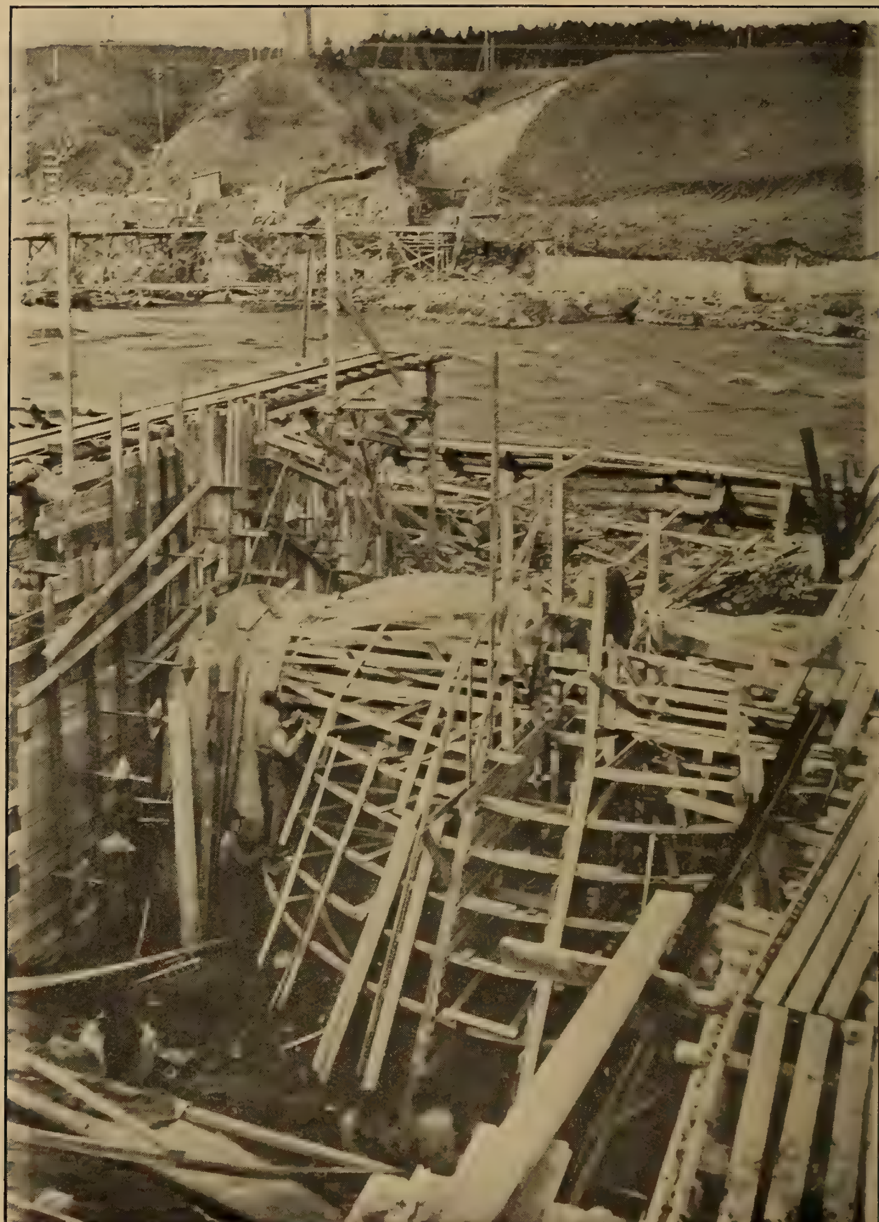
To utilize the energy which has heretofore run to waste at the Stop falls, there is nearing completion at Mockfjärd another important station. This has been blasted in the rock and opens to the light by a sloping tunnel, which serves as a stairway and conduit for electric cables. From the power station the water is carried away through two parallel tunnels, each nearly a mile long. There will be four turbines, of 4,000 H. P. capacity and 235 revolutions per minute, mounted on horizontal shafts direct coupled to the generators. These latter are to be built for 6,000 volts and 70 or 60 periods. The current will be transformed to 50,000 volts and transmitted to the Grängesberg and other neighbouring mines.

At the Gysinge falls about 700

KVARNSVEDEN DAM AND POWER STATION



PLAN AND SECTION OF THE POWER STATION AT BULLERFORSEN



DETAIL OF THE DAM AT BULLERFORSEN

Showing the wooden forms used in stamping the hollow body of the dam. To the left is a stamped column, and close to it the arches joining the next column.

H. P. are at present utilized, for the purpose mainly of electric steel-smelting according to the Kjellin method. The dam and power station at Söderfors include no features of special interest; of the large amount of energy available from the falls about 2,000 H. P. are at present utilized in driving motors at the Söderfors Steel Works, famous for its manufacture of high-class steel from Dannemora ores.

No more forcible illustration can be offered of the vastness of Sweden's natural wealth in rivers and waterfalls than is to be found in circumstances associated with the twelve falls to which reference has just been made. All are formed by a single river, they govern but a small district, and yet in the aggregate they are capable of furnishing electrical energy equivalent to not less than 175,000 H. P. North of them, however—to say nothing of Central or South Sweden—there are ten rivers, quite comparable with, or even superior to, the Dal in respect of hydro-electrical development. In the Lule Alf, for instance, the State alone possesses waterfalls estimated to be capable of yielding 170,000 H. P.

Among the larger falls in the Dal River not mentioned above is that at Näs, where an important and excellently-equipped power station has existed for several years. It is owned and operated by the Horndal Iron & Steel Works Company, but the greater part of the energy generated is distributed among other large industrial establishments. The giant's share goes to the well-known iron and steel works at Sandviken, all the departments of which are now operated by electric power.

The distance from Näs to the works is about 28 miles, and a transmission voltage of 20,000 volts is employed. The power taken out for the requirements of Sandviken amounts to 2,700 H. P., and is generated by six units each of 450 H. P., four other units of the same capacity supplying power to other consumers. Each unit consists of a pair of vertical-shaft turbines, which, through cog-wheel bearings, transmit their power to another vertical shaft, on which the generators' rotating field is mounted. This arrangement of gearing, to increase the speed of the generators, has been rendered necessary by the low fall, namely, 12 to 14 feet. The turbine speed is 64 revolutions per minute and that of the generators 215 revolutions per minute. The generator voltage is 660 volts at 50 cycles, and each generator has a corresponding transformer to step up the tension to the

THE DAM AT BULLERFORSEN, SHOWING THE ARCHES COVERED WITH WOOD

THE DAM AT BULLERFORSEN, SHOWING THE ARCHES DOWN STREAM

line voltage. There are two magnetizing generators of 66 H. P., each direct coupled to its respective turbine.

At Sandviken the whole of the energy is transformed to 500 volts, and from the transformer house the current is led to the various parts of the works through underground cables. The motors number about 140, most of them being of small size, full advantage being taken of the benefits of distributed separate driving. Of the five installed in the rolling mills, two of 150 and 600 H. P., having speed regulation, are

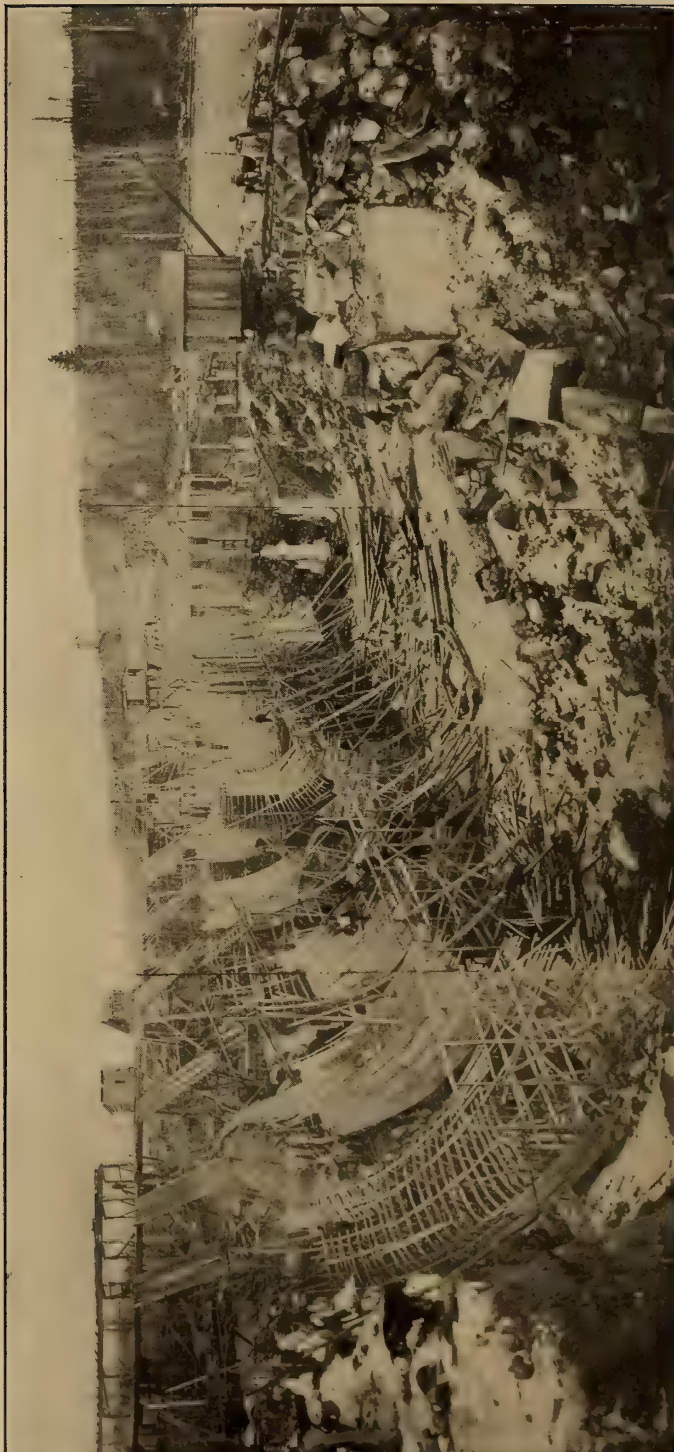
the most noteworthy. All manipulations for regulating the speed of these are effected by means of controllers of the tramway type.

Much attention has been devoted in Sweden during recent years to the question of railway electrification and the utilization therefor of the nation's abundant wealth of waterfalls and peat-bogs. So far, the movement in these directions has been slow and intermittent. During the course of the discussion, however, as the result of governmental and private investigations, tests and estimates, much valuable information has been gained, which cannot fail to be very helpful to the elaboration and consideration in the near future of definite and important projects. So conclusive, indeed, has seemed the evidence already to hand of the feasibility and economy of schemes tentatively formulated that there has been a tendency, in many quarters outside Sweden and even in that country itself, to assume that the question is more advanced than is actually the case.

With few exceptions, the so-called electric railways now in operation in Sweden should rather be described as tramways, are employed for passenger or goods traffic over distances seldom exceeding 10 miles, and are usually constructed with continuous current of 500 to 600 volts. Between Borensberg and Klockriks, however, on a section of a private railway company in Central Sweden, there was last year completed a single-phase electric railway, to which single-phase current is delivered at a pressure of 20,000 volts and at 25 cycles from the power station of the Motala River Power Supply Company. The contractors for the electrification were the General Electric Manufacturing Company, and the results have been considered so satisfactory as to warrant expectation that the system will be extended to the company's entire line.

PART OF THE DAM COVERED WITH GRANITE BLOCKS, BULLERFORSEN

In 1904 the Riksdag appropriated a considerable sum for experimental purposes in connection with the long-proposed electrification of certain of the State railroads. For the purpose of these trials temporarily equipped roads were constructed in



THE TURBINE DAM AT BULLERFORSEN. SHOWING THE FORMS USED FOR CASTING THE SUCTION PIPES OF THE TURBINES

the neighbourhood of Stockholm—one between the central station and Järfva for local service and another between Värtan and Tomteboda for testing purposes. The results of practical working and a series of very thorough investigations amply demonstrated the economy of trunk-line electric traction and the suitability of the system to the demands of Swedish railroads. So conclusive, indeed, was the evidence on these points that the commission of inquiry submitted a report recommending the early electrification of no fewer than 1,300 traffic miles; in other words, of all the State railways with the exception of three lines, situated south of Bollnäs, a station on the Ljusnan River, about 150 miles north of Stockholm.

The commission recommended the use of single-phase alternating current, the conductors carrying a pressure of 50,000 volts in the feeders from the power stations and 15,000 volts in the contact wires. Both power and contact wires were to be carried on the same poles, spaced 85 feet apart, and placed alternately on the right and left sides of the railway. Between the power stations and the railways the energy would be transmitted on two lines, independent of each other, carried on iron supports bedded in concrete foundations and spaced 366 feet apart. For supplying the various sections with power there were to be five hydro-electric stations—the most northerly at the Elfkarleby falls, on the Dal River; one on the Hammarby falls, Jäslean River, in a central position; a third on the Motala River, between lakes Norby and Roxen; Trollhättan, on the Göta River; and a fifth at the Korsefors falls, in the Lagan River, in the extreme south. The scheme also embraced several auxiliary peat power stations and thirty-seven transformer stations situated along the railways at distances of some 30 miles.

THE STOP FALLS AT MOCKJÄRD

The aggregate cost of the project, based on the traffic of the year 1905 and on an increased traffic of 60 per

cent. expected in 1920, was estimated as follows:

	1905	1920
Transmission lines, transformers, etc.	£2,070,000	£2,610,000
Power stations	1,330,000	1,540,000
	£3,400,000	£4,150,000

and the annual expenditure at, respectively, £284,000 and £366,000, made up of the following amounts:

	1905	1920
On transmission lines, transformer stations, staff, etc.	£152,000	£191,000
At power stations	126,000	168,000
Management	6,000	7,000

On the same basis, the annual saving resulting from the introduction of electric traction was estimated as follows:

1905	1920
£331,000	£820,000

Satisfactory as this report was admitted to be, and notwithstanding an accumulation of evidence that many of the lines involved have, under existing conditions, reached their limit of development, no action has yet been taken to carry the recommendations into effect. Within the near future, however, I am given to understand, definite plans will be formulated for the electrification of the more important State railways. The first line to be taken in hand will be, in all probability, that between Kiruna, the centre of the great iron ore fields of Lapland, and Riksgransen, on the Norwegian frontier, a distance of about 81 miles. It is a section of the Lulea-Gellivare-Narvik Railway, completed in 1903, over which large and ever-growing quantities of iron ore from the rich fields of Gellivare, Malmberget, Kirunavara and Luossavaara are transported for export from the terminal ports—Lulea, on the Gulf of Bothna, and Narvik, on the Atlantic. To meet the present largely increased demands upon it and enable the management to run heavier trains at higher speeds, the Kiruna-Riksgransen section, especially, must be either reconstructed with double tracks or electrified, and of these alternatives the second seems from every point of view the wiser and more economical.

POWER STATION AT MÄS, DAL RIVER, 6,300 H. P., 20,000 VOLTS, SUPPLYING ENERGY TO THE HORNDAL AND SANDVIKEN IRON & STEELWORKS CO., EQUIPPED BY THE GENERAL ELECTRIC MFG. CO. OF SWEDEN

The adoption of electric traction

on this line, far above the Arctic circle and the most northern railway in the world, will be an event of considerable importance in the history of electricity, and cannot fail to stimulate in marked degree the demand for similar action in respect of other Swedish railways. Nor will it be without value as a practical illustration of the unbounded potentialities of Sweden's wealth of waterfalls, not limited to a few specially favoured regions, but at hand and only awaiting development to benefit every province.

NORTHERN SECTIONS OF THE LULEA-GELLIVARE NARVIK RAILWAY

In bringing these articles to a conclusion, it is at once a duty and pleasure to express my sincere acknowledgments to the numerous correspondents who have aided me in the work. For much vluable information, or for placing at my disposal interesting plans, drawings and photographs—many of which, owing to exigencies of space, have been regretfully put aside—I have to especially thank several government departments, the president of the newly - created Royal Waterfalls Board, the administration of the State Railways, Mr. F. Holmgren, chief engineer of the Trollhättan power station; Mr. R. Dahlander, chief engineer of the Stockholm electricity works; the managing director of the Stora Kopparbergs Company; Mr. C. Kjellstrom, superintendent of the Swedish Cement & Concrete Company, under whose supervision many of the most important dams for hydro-electric installations have been built; Mr. Sven Lübeck, one of Sweden's leading hydraulic engineers; Professor Arrhenius, of Stockholm University; and, last but not least, several of the power-supply companies and principal establishments associated with the Swedish electro-technical industry.

SMOKE ABATEMENT CONFERENCES AND EXHIBITIONS

A VERY large number of manufacturers and business men are apt to wax sarcastic and skeptical when smoke-abatement conferences and exhibitions are mentioned in their hearing, and are disposed to argue that black smoke, like poverty, is one of the inherent and permanent evils of our present industrial organism.

Although very widely held, this opinion is too often based either on prejudice or ignorance. In neither case is it creditable to the intelligence of the man who believes it and gives public utterance to it in the presence and hearing of his fellows.

For there is no doubt whatever that nine-tenths of the smoke emitted from the chimneys of factories and industrial undertakings is preventable, and that its emission at the present time shows waste and extravagance in the use and combustion of fuel. If proof be asked for in support of this statement, it may be found in the annual reports of the Hamburg Verein für Rauchbekämpfung und Feuerungsbetrieb; in a report published by the Syracuse (U. S. A.) Chamber of Commerce in 1907; and, finally, in the experience of many individual manufacturers on both sides of the Atlantic, who have proved up to the hilt that in the majority of instances the suppression of black smoke is accompanied with a reduction in the cost of fuel.

Smoke-abatement conferences and exhibitions are, therefore, not without their value, for they serve to draw public attention to the subject, and they may effect much good by removing the prejudice and ignorance which are, in the majority of instances, the only bar to progress and reform.

The smoke-abatement conference and exhibition held in Sheffield during March of the present year were noteworthy in two respects. In the first place this is the first time that the local authorities in one of the larger manufacturing cities of England have organized such an undertaking, and, in the second place, the special problems connected with the production of smoke from metallurgical and annealing furnaces were recognized and discussed at some length.

The smoke problem of London is one chiefly due to the domestic fire-grate, and for that reason the conference and exhibition held there in the winter of 1905 were productive of little visible result. To an Englishman, the open fire-grate, with its smoky flame, is one of the most essential features of his domestic happiness and comfort. Unfortunately, no modified form of open fire-grate which will burn bituminous fuel without smoke has yet been devised, although many experiments have been made in this direction. Since the American method of heating rooms bv hot air or by steam pipes is unpopular in England, and the coke or anthracite stove is equally unacceptable, the only hope that London may in time possess an atmosphere equal in clearness to that of New York, Paris or Berlin lies in the use of partially coked fuels like "coalite," or in the extended application of a cheap gas for heating purposes. Progress is no doubt occurring in both these directions, and this will grow more rapid as the supplies of these two forms of fuel are increased and cheapened. The domestic smoke problem, in fact, not only in London, but in other large towns and cities of the United Kingdom, is

likely to be solved along these lines.

In the larger centers of manufacturing industry, however, both in England and America, the problem presented by manufacturers' and factory smoke is the more important one, and it may be useful to record what was said upon this subject at the Sheffield conference.

Sir Oliver Lodge, who opened the exhibition of smoke-abatement appliances, referred to the use of a smoky flame for metallurgical purposes, and stated that, though objectionable, this method of heating was sometimes undoubtedly economical. But there were many substances which would radiate heat better than carbon, and he advocated the application of the incandescent gas-mantle principle to the heating of water in steam boilers and of metals. It may be mentioned here that the exhibit of the Incandescent Heat Company showed the application of this method to the heating of steam boilers, and that in this case the appliance consisted of a long horseshoe-shaped cast-iron tube built up in sections and lined inside with fire-brick. Independent tests made by Professor Burstall, of Birmingham University, with this appliance fitted to a dry-back marine type of boiler show that the efficiency of the boiler was raised from 55 per cent. to 70 per cent. by the use of the incandescent tube, the fuel used being a cheap slack, containing on the average 16 per cent. of ash, while no smoke was produced at any period of the combustion process.

Mr. T. Scott Anderson, of Sheffield, who read the first paper at the conference for manufacturers, dealt with the subject of the heating of metallurgical furnaces at some length, and referred to Sir Oliver Lodge's remarks upon the use of highly heated solid bodies for communicating heat by radiation to cold metal surfaces in their vicinity. The following extract from this portion of Mr. Anderson's paper will be read with interest, both in England and in America:

"I hope these remarks from such an authority will permanently dispose of that very ancient belief that the object to be heated must of necessity be in contact with the fire or flame.

"When this is realized and acted upon we shall hear no more of those statements which have been too freely made, that a smoky flame is essential to certain metallurgical operations.

"In Germany and France these radiation furnaces are employed with complete success. The temperatures which can be obtained, adjusted and maintained are considerable, being from 1,050 degrees C. to 1,850 degrees C. (1,922 degrees F. to 3,360 degrees F.).

"Gas is employed in these furnaces, being first perfectly mixed with the exact amount of air necessary for complete combustion; this mixture is then burned as desired.

"In some cases it is highly necessary that the products of combustion shall not be in actual contact with the metal being heated, and in such a case the furnace is designed with a double circulation of the flame, which first rises between the hearth of the furnace and a wall of dolomite briquettes and then descends, so that the briquettes are very nearly at the same temperature as the interior of the furnace.

"Almost any metallurgical operation can be conducted in such a furnace, the saturation of the metal is assured, and there is an entire absence of smoke and dirt.

"In Remscheid the success has exceeded the anticipation, and where once huge smoky furnaces were employed they now have the cleaner, more economical and much more scientific method of treatment."

Mr. Booth, who followed Mr. Anderson, gave details of the course of special lectures he had delivered in London in the winter of 1906-1907 on the principles of hand-firing and mechanical stoking, these lectures being delivered under the auspices of the London Coal Smoke Abatement Society. These lectures were attended

chiefly by stokers and engineers in charge of boiler installations in and around London, and aroused much interest. Mr. Booth advocated the inauguration of similar lecture courses in all large industrial cities, and no doubt such courses would help to educate the stokers in the proper performance of their duties.

Mr. Kershaw, the third and last of the official speakers at the conference on March 3, gave a brief review of the aims and work of the Hamburg Smoke Abatement Society. The membership of this society, which is an entirely voluntary and self-supporting organization of fuel consumers in the city of Hamburg, has grown from 48 to 258 in the short space of five years, and the engineer-chemists of the society have now 717 steam boilers and several bakeries under their control. A very important part of the work of this society lies in the training and supervision of stokers, and two instructors are retained on the permanent staff of the society for this special work. The whole of the stokers in charge of the 717 steam boilers belonging to members of the society have thus at one time or another received skilled instructions in the proper performance of their work, and by means of regular visits and tests by the officers of the society they are kept up to the highest level of efficiency. The instruction is given generally at the plant where the stoker is employed, and this method of training and supervision should certainly commend itself to steam users in this country. As an example of the improved efficiency obtained by proper and skillful stoking, Mr. Kershaw gave the following figures from the 1907 report of the society:

"The two boilers were of the Lancashire type, were quite enclosed by brickwork, and were provided with automatic apparatus for regulating the supply of secondary air behind the bridge. The fuel was Westphalian unscreened coal from the Hugo mine. The trials lasted each eight hours, during which period from 2,500 to 3,200 kilogrammes of coal were consumed, equal to from 54.5 to 69.7 kilogrammes per hour per square metre of grate area. The first test was made with the usual stoker working under normal conditions. The working efficiency of the boiler was only 58 per cent., 28 per cent. of the total heat value of the fuel being carried away by the exit gases.

"One of the society's instructors was then given charge of the two boilers during the second eight-hours' trial, and the efficiency rose to 72 per cent., while the heat losses in the exit gases were reduced by one-half. The third trial was made with the ordinary stoker after some instruction had been given to him as regards the best methods of firing, etc. The efficiency in this case was 67.7 per cent., or nearly 10 per cent. better than the first test, although not so good as the efficiency attained in the second test. The drop of 5 per cent. was partly accounted for by the fact that the rate of combustion was higher, and the exit gases were passing to the chimney at 275 degrees C. (527 degrees F.), as compared with 250 degrees C. (487 degrees F.) in the earlier test.

"Other tests, in which full details are given in the 1907 report, show gains of 7.4, 8.9, 15, 5.6, 6.6 and 12.9 per cent., respectively, due to the substitution of trained for untrained men."

The chief points raised in the discussion of these three papers related to the use of improved methods of heating the annealing and reheating furnaces, which are so largely employed in the steel armour plate and allied manufactures.

Mr. Victor Stobie, of Sheffield, stated that his firm had obtained very good results with furnaces heated by producer-gas, and urged the manufacturers of steel armour plates, etc., to experiment in this direction. Although admitting that certain classes of steel could not be heated

up slowly without the production and emission of black smoke, Mr. Stobie yet believed that the evil might be largely reduced by the means he had suggested.

Mr. Senior, another Sheffield manufacturer, controverted this opinion, and stated that only the cheaper classes of steel could be heated in this way.

The impossibility is, of course, more apparent than real. The oxidizing effect of the gases, when combustion is perfect, has, it may be admitted, bad effects upon the steel, hence the use of smoky flames containing no free oxygen for reheating the steel. But there is no actual necessity that the hot gases should come into contact with the metal, and the principle of heating by radiation, as advocated by Sir Oliver Lodge and Mr. Anderson, can be easily adopted for the reheating furnaces. Further, by this system of heating the chamber holding the metal could in many cases be filled without difficulty by a reducing gas, so that all possibility of oxidation would be avoided. The difficulties, in fact, are largely imaginary, and have never really been faced by the majority of steel manufacturers. If a resolute attempt were made to overcome them, the use of gas-heated furnaces for metallurgical purposes would become general.

Limits of space will not allow the writer to deal at any length with the papers read at the conference of local authorities on March 8, or with those read at the final conference on March 15, when the members of voluntary associations gathered in the exhibition building. The practical outcome of these two conferences was the adoption, *nem. con.*, of a resolution to form a provisional committee, consisting of representatives of local authorities, manufacturers and voluntary associations, for the purpose of putting the smoke-abatement movement in the United Kingdom on a permanent and national footing.

Committees and conferences are useful, as stated in the introduction to this article; but the education of the individual stoker and his employer is the essential reform necessary to solve the industrial smoke problem; and if the provisional committee loses sight of this fact it will achieve absolutely nothing.

That this fact is recognized in America is proved by the publication of the Syracuse Chamber of Commerce already referred to and by the holding of a fuel conference at the University of Illinois on March 11, 12 and 13 of the present year. Although this conference was chiefly concerned with the minimization of the dangers incident to the mining of coal, the proper combustion and utilization of coal were not lost sight of, and one day was devoted to the reading of papers and discussion upon these very important subjects. Mr. W. L. Abbott, chief operating engineer of the Commonwealth Edison Company; Mr. A. Bement, the well-known consulting engineer, of Chicago; Mr. D. T. Randall, of the Technological Branch of the United States Geological Survey; Mr. R. H. Kuss, Assistant Smoke Inspector of Chicago; Mr. Edward Cheney and Mr. Edward Taylor, of the Fuel Engineering Company, of Chicago, and Mr. T. M. Snodgrass took part in this conference, and more than 100 representatives of the interests concerned either in the production of fuel or in its utilization were present at the gathering.

There is some talk of holding a conference and exhibition similar to the Sheffield one in Manchester, England, during the winter of the present year, and one can only trust that this project will be successfully carried out.

THE ARCHITECTURE OF HYDRO-ELECTRIC STATIONS

By Frank Koester

T is a matter for comment that electrical and hydraulic engineers often give but little attention to the architectural features of the buildings in which the results of applied science are effected. It is true that material progress has been made in recent years in the design of buildings for hydro-electric plants and their sub-stations; but there is still much room for improvement, and in the United States especially there are many such structures in which the attention given to architectural effect and to convenience and personal comfort of the operatives is secondary to that given to the engineering features.

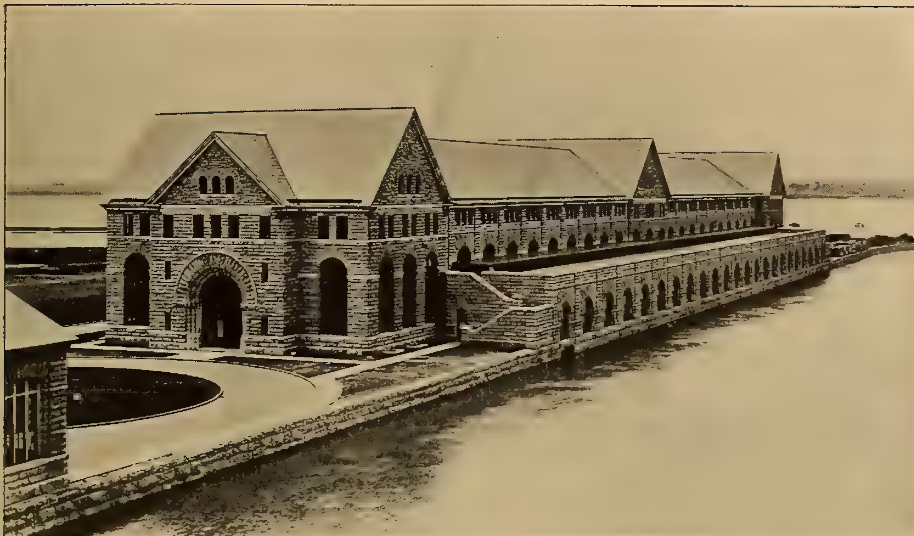
The primary considerations governing the design of the buildings are naturally those concerned with the shelter and protection of the machinery and the operatives. An ornamental building will not directly increase the efficiency of the plant nor add to the comfort of the employees; but, at the same time, the character of the building does have a decided influence upon the *morale* of the operative force, on whose efficiency the efficiency of the entire plant directly depends.

As a general rule, the ultimate aim in the design of a hydro-electric plant is the generation of electric current upon a commercial and economical basis. It is desirable, however, that the buildings in which the machinery is housed for the development of one of the great sources of power in Nature for the use and convenience of man should be of aesthetic design, because they indicate, in a measure, the prosperity of the country.

There exists, undoubtedly, a feeling, not only among the general public but also among many engineers and architects, that the development of water power necessarily destroys the beauty of the surrounding locality; but this assumption is by no means correct. Doubtless the multiplicity of box-like structures in existence afford ample evidence of the lack of association of the engineer and the architect, and if the hydraulic and electrical engineers continue to erect such plants the development of an antagonistic sentiment is to be expected and justified. There are exceptions, however, which prove very clearly that the effectiveness and beauty of the scenery may be improved by the erection of the buildings of a hydro-electric plant.

In this connection, and before citing examples to prove the above proposition, it may be of interest to give a brief abstract from the report of the commissioners concerning the franchises to be granted to the various electrical development companies on the Canadian side of Niagara Falls:

"All of the works and structures connected with the electrical power projects have been designed with the object not only with doing the least possible injury to the scenic conditions, but the commissioners are confident in the belief that when the several works are completed the consensus of opinion by the vastly increased number of visitors that are



EXTERIOR OF POWER PLANT NO. 2 OF THE NIAGARA FALLS POWER CO.

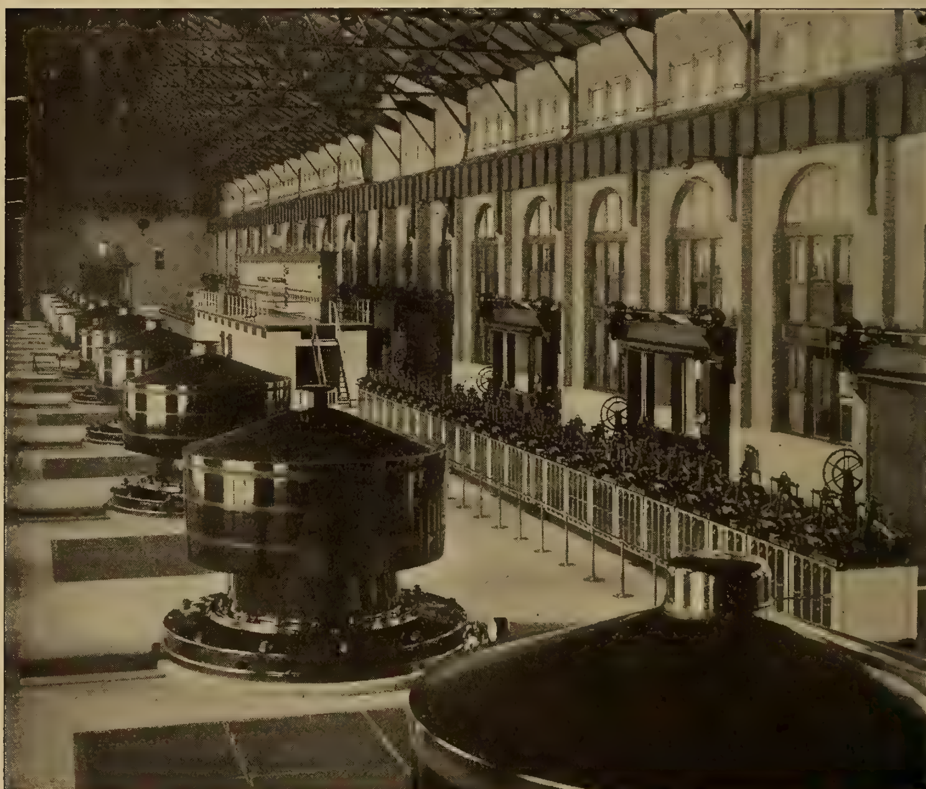
ENTRANCE HALL OF POWER PLANT NO. 2 OF THE NIAGARA FALLS POWER CO.

expected to visit the park will abundantly sustain them in their contention that the park, as a whole, with its wealth of electrical machinery, will then be of ten-fold greater interest to the great majority visiting it."

The possibilities of giving an hydro-electric plant a superior architectural appearance are much greater than in the case of a steam-power plant, because there is no handling of coal and ashes and no production of smoke.

A building intended to house a power plant should not be too ornate, such as is often the case in Europe; simplicity in design and harmonious arrangement, taking into account the surroundings, are matters of prime importance.

The interiors of the rooms containing the generating machinery and switchboards should be kept as light as possible, and it is advisable to apply a smooth coating of cement plaster to the walls, followed by a white finish. A still better effect is secured by facing the walls with enameled tiles, using a wainscoting of some contrasting colour. The steel columns necessary for the support of the runway for the traveling crane may be converted into pilasters, thus breaking up the monotony of a blank wall. An excellent effect is obtained by using tiling of cream colour, with wainscoting and ornamental panels of olive green. Other colours may well be chosen to meet the taste of the designer and to harmonize with the floor or with other local conditions.



INTERIOR OF GENERATING ROOM NO. 2, NIAGARA FALLS POWER CO.

Probably the best floor finishing for the generator room is of tile or mosaic. This does not absorb oil, and, being smooth, it is easily kept clean, and presents a very handsome appearance; the appearance of such floors is heightened by the use of effective borders.

Penstock connections to turbines are frequently laid in trenches and covered by plates; these connections should run parallel to the ends or sides of the building, if possible. It is poor engineering to have the branches of the penstock imbedded in the concrete floor, and it is still worse to permit portions of flanges to project above the floor.

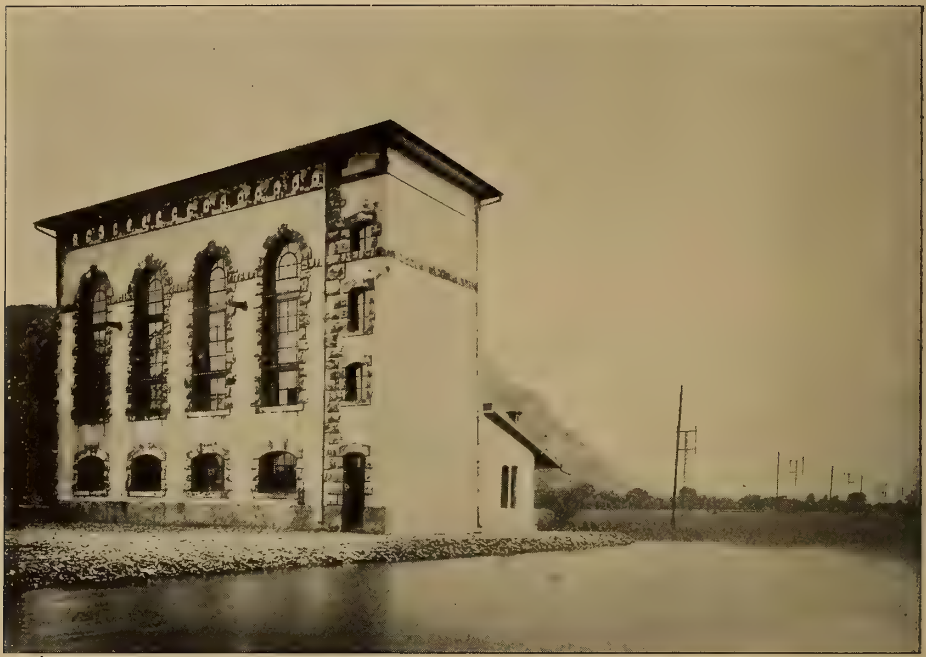
If a common concrete floor is used, it should be of the granolithic finish and of a dark colour, in order to render any dripping of oil and water inconspicuous.

The arrangement of the windows, as well as of the pilasters by which the runways of the crane are supported, should be symmetrical with regard to the turbine sets. Arched windows are to be preferred, and, if of large design, they should be paneled to harmonize with the general design of the building. Very often the design and arrangement of the windows spoil the effect of an otherwise well-designed structure.

Doors must be massive, and should be well paneled, and their appearance will be greatly improved by the addition of bronze trimmings. Since fireproof doors are required in many cases, it is desirable to use entirely metallic doors of ornamental design in place of the ordinary dull, fireproof construction.

Since switchboards bear costly instruments of scientific character, the

TYPICAL ALPINE HYDRO-ELECTRIC PLANT



SUBSTATION AT STANSSTAD, SWITZERLAND

EXTERIOR OF HYDRO-ELECTRIC PLANT, STUTTGART, GERMANY

DAM AND HEAD RACE, SILLWERKE, TYROL

boards themselves should be of corresponding artistic design. Good construction includes the use of ornamental ironwork, faced with white marble or enameled slate. In Europe, for central and sub-stations, white marble panels are in favour, while in the United States enameled slate is in vogue. Care should be exercised to have the instruments symmetrically disposed, and when pedestals are used they should be properly grouped, so as to give a good effect, without sacrificing convenience of operation.

The traveling crane serving the generator room may not be classed as an architectural feature; but even this unpromising detail may yield, in some degree, to proper treatment. It should be designed in a way to conform to the appearance of the roof truss, and in this respect the latticed type has a better appearance than the heavier-looking box girder in general use.

In arranging the ventilation of the generator room the use of louvres with swinging windows should be avoided in the roof above or near current-carrying apparatus, such as generators, motors and switchboards. The windows on the switchboard side of the room must be fastened and no provision made for opening them, or else a locking system should be provided. This precaution is necessary, otherwise short-circuiting may occur by reason of rain or dust particles being blown in from without. In cases in which air-blast transformers or storage batteries are installed, the fumes from the latter should be carried through special ducts up through the roof, while the discharge from the former can find its outlet through windows and other ventilating openings.

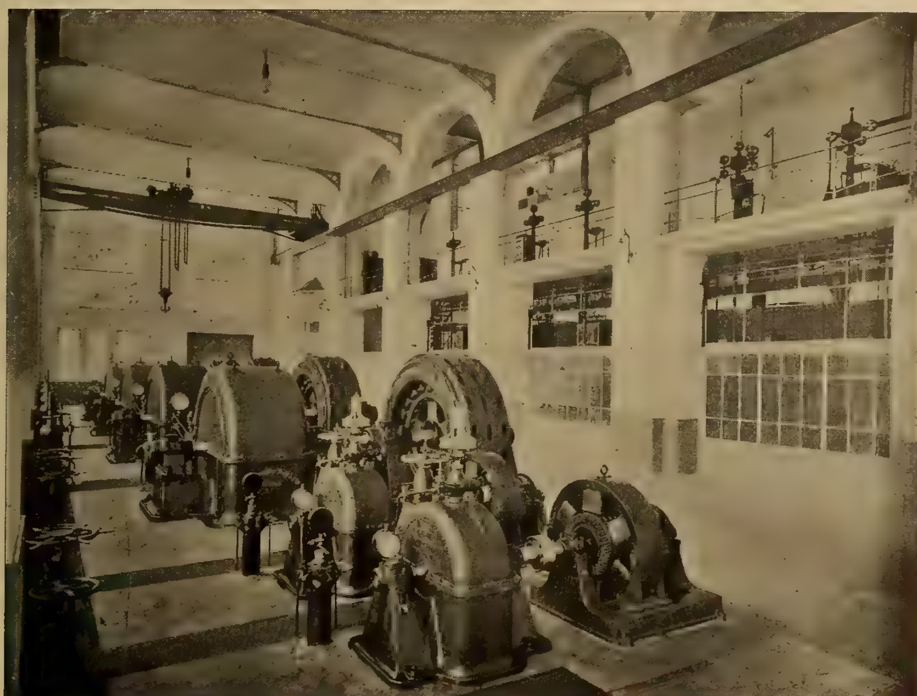
The wiring for lighting purposes should be as inconspicuous as possible. It is advisable to have two sets of wiring installed, one coming from

EXTERIOR OF OBERMATT PLANT, LUCERNE, SWITZERLAND

the generators and the other from a storage battery, so that in case of a serious shutdown there will be no difficulties from lack of light.

When the plant is situated in a temperate latitude it will be necessary to provide a heating system, either by steam or by hot water. The latter method has serious disadvantages, both on account of the large amount of radiating surface necessary and because of the danger of exposed pipes becoming frozen. Steam heating has many advantages, costing less for installation, and being more convenient for handling. The heating coils may be arranged either on the ceiling or under the windows, the latter position being the more efficient and presenting the better appearance. Every power plant should be provided with a well-equipped lavatory, with plumbing of good, substantial material, and enameled basins, bowls and sinks; bowls are to be preferred to sinks. Toilet floors should be tiled, and the whole interior should preferably be of a white finish, this rendering dirt conspicuous and rendering easy the enforcement of cleanliness. Lockers should be installed, and ample opportunity given for the necessary changing of clothing and maintenance of personal cleanliness on the part of the operatives.

A few examples will serve to show the possibilities in the co-operation of the engineer and the architect in the design of hydro-electric plants.



INTERIOR OF GENERATING ROOM, OBERMATT PLANT, LUCERNE, SWITZERLAND

One of the foremost hydro-electric stations in America, both as regards capacity and with respect of architectural features, is that of the Niagara Falls Power Company. The superstructure is composed of rough-faced granite blocks, with a slate roof. The interior design of the generator room is in keeping with the exterior, while the entrance hall has

POWER PLANT AT TIVOLI, ITALY

been more elaborately treated. The building, as a whole, is tasteful in design and typical of its purpose, namely, that of a power plant.

In some of the European stations the ornate character of the design may seem exaggerated, as, for example, in the case of the hydro-electric plant of the city of Stuttgart. This is in the Gothic style of the fourteenth century, a variety in much favour in Continental practice, the approach from the street being in harmony with the general structure.

EXTERIOR OF THE MUNICIPAL HYDRO-ELECTRIC PLANT, GENEVA, SWITZERLAND

SUBSTATION AT DULUTH OF THE GREAT NORTHERN POWER CO., DULUTH, MINN.

This plant is provided with four turbines, each of 300 house-power, and with a storage battery of 300 ampere-hours. A plant of this size would be considered too small in the United States to demand any special architectural treatment.

The Stuttgart plant has much elaboration in the nature of fancy cornices, projections, offsets in the building, etc.; but such expensive irregularities are by no means necessary to secure a pleasing architectural effect. The plant at Obermatt, near Lucerne, in Switzerland, of which both the exterior and interior are shown, is modeled rather on the style of a mediæval castle, following the general lines of existing remains of such structures. Attention may be called to the novel design of the windows of this building.

An example of the modern, so-called "secession" style of architecture as applied to a power plant is seen in the building of the Urfttalsperre, at Heimbach, Germany. The entire design, including pilasters,

roof-trusses, switchboards, etc., is in the same style, and the towers shown in the wings in the exterior view might be taken for the bases of smokestacks. The whole structure, both as regards the exterior and interior, is of unique design, and forms a bold departure in power-plant practice.

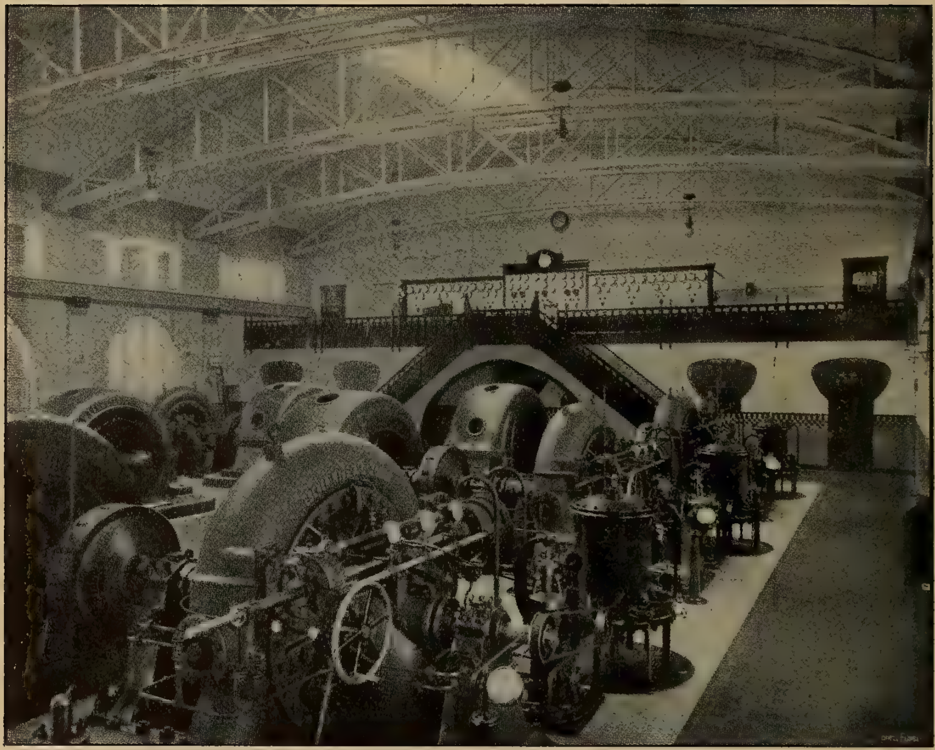
CENTRAL STATION, "HEIMBACH," GERMANY

The introduction of individual designs for the various details of power-plant equipment, such as switchboards, etc., has long been in vogue for private and isolated plants, and this feature is now appearing in large central stations, this practice being early noticeable in Continental plants.

One of the most picturesque hydro-electric power plants in Europe is that at Tivoli, Italy, situated on the Tiber, and supplying electric current to Rome. The building itself, with its few arched openings, is of simple design and well adapted for the climate. The head-race is designed in the style of an ancient Roman aqueduct, and is provided to deliver a greater quantity of water than is needed for the power plant in order to supply the waterfall. This plant adds greatly to the scenic beauty of the vicinity, thus partially compensating for the fact that the commercial benefit of the installation inures, not to the neighbourhood, but to the city of Rome.

An examination of the illustrations will show the correctness of the assertion that the presence of a hydro-electric plant does not necessarily impair the beauty of the locality, and that a good effect may be obtained with a comparatively small expenditure of money. In many instances it is evident that the development of the hydraulic power may be used also to improve the natural attractions of the situation.

It must not be assumed that the treatment shown in the various illus-



GENERATING ROOM OF CENTRAL STATION, "HEIMBACH," GERMANY

trations covers the possibilities of the various buildings, but it may be affirmed that in nearly every instance a pleasing effect can be secured with little or no additional expense; the principal necessity lies in a proper knowledge of architectural principles and their application to the local conditions. At the present time, when both engineering and architecture have attained such a high degree of development, it is indeed strange that we see every year so many unattractive structures erected in connection with the development of hydro-electric plants, while by a proper association of both science and art such excellent effects might be attained.

MECHANICAL APPLIANCES FOR TRACK-LAYING

By J. F. Springer

RECENT DEVELOPMENTS IN MACHINES FOR THE CONTINUOUS CONSTRUCTION OF PERMANENT WAY

IN the construction of the permanent way of a railway there is, of course, a great variety of work to be done. In the preparation of the line there is the regular work of excavation, involving the digging and removal of sand, gravel and earth, either by the ordinary pick and shovel or by steam shovels and excavators. Where the line runs through more or less solid rock, recourse must be had to drilling and blasting, following which the steam shovel may complete the work. At another point, instead of a cut, a filling-in must be made; at still other points, bridges or viaducts must be constructed or tunnels bored. When all this construction has been completed and the surface brought to level and form, we have the foundation for the railway. This is the sub-grade, upon which are carried the ballast and the track. The track, consisting of ties and rails, may now be laid.

But in carrying out this operation difficulties arise. The ties are short and of moderate weight, and so may readily be handled by workmen. The rails, on the contrary, are 30 or even 33 feet long, and weigh from 650 to 715 pounds in the case of 65-pound rails to 1,000 or 1,100 pounds for the 100-pound size. Thus they present somewhat of a problem in handling. Now of course the construction train which transports rails and ties to the most advanced point possible may have its engine and tender at the rear and the rail cars at the very front. It is thus possible to bring the rails close to the point where they are needed. But consider a moment. Even if the rails are delivered from the very head of the train directly to those engaged in the actual work of putting them in position, a complication will soon arise. Just as soon as all the rails on this front car have been taken off it will be necessary to withdraw the train to some switch where the empty cars may be gotten rid of, or the men on the train engaged in handling the rails will have to get them from the next car further back and carry them over the empty, or they must be thrown off the cars upon which they are loaded and brought to the head of the track after the train has withdrawn sufficiently for this purpose. Perhaps the very best practice that can be adopted where special machinery is not employed is the following procedure: The construction train, loaded with rails on the forward cars and with ties on the rear ones, is run to the head of the track already constructed. Rails and ties are now thrown off at the side, whereupon the train withdraws. Teams bring the ties to the places where wanted. The rails are picked up and carried by hand until one or

two lengths are laid. Other rails are then conveyed on a tram-car, which runs on the new track and may be pushed by hand or drawn by a horse. This system, it will be observed, involves re-handling both rails and ties.

It will be seen from the foregoing that almost any method of getting the material to the front without the aid of special devices seems to be inevitably handicapped either by the necessity of handling rail and tie a second time or by the requirement of getting the bulk of the rails over one or more empty cars, or by the delay of moving back to a switch; or, to sum the matter up in other words, the very train which brings the material up is in its own way in making delivery. There is a further disadvantage attaching to any procedure in accordance with which a preliminary delivery is made over the side of the cars. This is the lack of room in many situations. The road-bed may be a narrow shelf on a hill-side. There may be swamps to right and left. The line may pass over a trestle here or through a tunnel there. In all such circumstances any other procedure than delivery over the end of the train is pretty well out of the question.

Difficulties such as those outlined have been productive during the last twenty or thirty years in the development of mechanical means adapted to facilitate over-end delivery of both ties and rails. There are now in existence a number of systems which seek to accomplish this result. None of these is properly a track-laying apparatus in any strict sense. The track is laid almost, if not quite, entirely by the workmen alone. What the various machine appliances do is to put the material more or less perfectly where these workmen want it. Before passing on to describe in detail certain of the systems now in use, it may be well to point out just what hinders the construction of a machine to do the actual tracklaying. The apparent necessity which operates as this hindrance relates to the circumstance that the machine loaded with the material is seemingly compelled to run over the very track that it is engaged in constructing, so that, in some shape or other, the track which it is to use shortly beneath its truck-wheels is even now loaded above them. If it were possible to accomplish construction from the rear, no doubt an actual track-layer would either have been already evolved from the fertile brains of our inventors or would be a thing of the immediate future. However, the apparatus already developed are noteworthy appliances, and although they do not really perform the actual laying of the track, we shall not refuse to use the word "tracklayer" in referring to them.

It is not always speed of construction which makes the tracklayer desirable. With such apparatus the contractor is well-nigh independent of labour conditions, on account of the reduction in number of the workmen necessary. This is often a very important consideration. Several miles per day may be accomplished by non-machine methods. But a great army of men is needed. And so it has become not at all unusual to resort to machine methods.

Amongst the most effective apparatus is that of the Hurley Track-laying Machine Company, of Chicago. While this machine does not pay out completely finished track from behind, it is ever in motion forward, so that it is proper to describe it as a continuous layer. The movement of the machine measures the rate at which the track is being put down. To an onlooker it seems very slow, being about 21 inches or so per minute. This rate of advance, which is equal to about 2 miles per day, is capable of increase, being dependent not so much on the machine itself as upon the character of the labor employed as auxiliaries.

Of course, the track is not reeled off as a continuous finished piece. This seems almost impossible of achievement. It does, however, what

THE HURLEY TRACK-LAYING MACHINES

CLOSER VIEW OF THE HURLEY TRACK-LAYING MACHINE

other machines do, and apparently must continue to do—it furnishes the material to the men in front. But it accomplishes this in a very effective manner—so effective, in fact, that a few men accomplish great results with its aid.

To one who approaches the Hurley outfit from across country the machine at the head of the train has the appearance of some gigantic insect. There is, in fact, a projecting cantilever construction extending forward without support for a distance of 68 feet. Upon close approach, however, one sees that crossties are

FLAT CARS CARRYING THE CROSS TIES. THIS VIEW ALSO SHOWS HOW THE RAILS ARE DELIVERED. THE HURLEY TRACK-LAYING MACHINE CO.

HURLEY TRACK-LAYING MACHINE SHOWING HOW THE CROSS TIES ARE DELIVERED

being conveyed over the top, down an incline at the front, and are then let fall upon the roadbed; that is, upon the sub-grade. Below the head of the "insect," and where one would expect the mouth to be, rails are coming forth, two at a time. However, the rails are not, like the ties, allowed to fall approximately into place. They are seized by special tongs and lowered into position. The ties are placed more accurately in place by hand, and the spiking, bolting, etc., of the rails are likewise accomplished by hand. Upon looking more closely at the delivery of rails, it will be noticed that they do not come to hand singly. In fact, there are two continuous strips of rail coming from each side. That is to say, the 30-foot lengths are secured together by angle bars. However, there are but two bolts used with each angle bar. The bolt connecting the pioneer rail with the following one is withdrawn by hand and the other is loosened; consequently, the rails are finally delivered one at a time, and each with an angle bar loosely attached at its rear end.

There are two general methods of laying rails, whether laid by machine or hand. In the one, the joints of the two sides of the track are placed abreast of each other; in the other, each joint is placed opposite the center of the rail on the other side. With the Hurley machine the delivery of the rails is accomplished to suit either style of construction. This is possible from the fact that the mechanism which accomplishes the rail deliveries operates independently on the right and left sides.

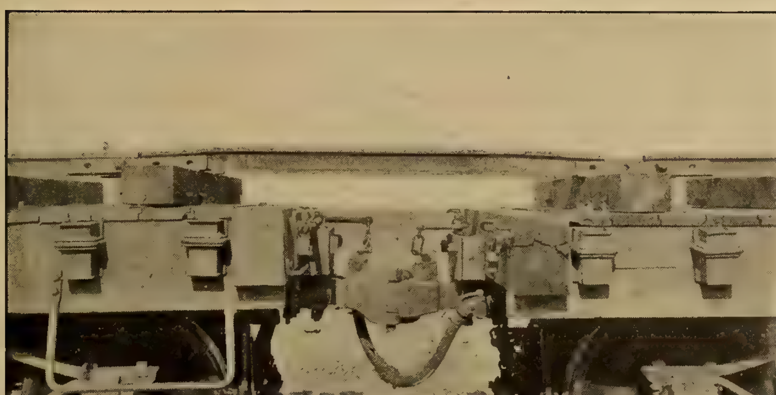
The main apparatus is all contained in the two forward cars. These constitute an immense affair, including the 68-foot cantilever. The machine supplies the motive power for its own propulsion as well as the operation of the conveying apparatus, containing two reversing engines, together with a boiler, coal-bin and water tank. To the rear of these special devices come the cars containing the cross-ties. Following them is the tool-car. After it are the cars carrying the rails. Altogether, there may be quite a train—amounting sometimes to thirty cars. No locomotive is needed, the entire train being controlled by the motive power supplied from the machine.

Looked at from the side, the hinder one of the two forward cars presents a peculiar sight. Just above the floor level one may see clear through the car and view objects beyond. Above this open space is a platform, on which are placed the coal-bin, water tank, etc. Through the open space below the platform rails and cross-ties pass on their wav to the front. And so, when we learn the *modus operandi,* the reason for the singular appearance of this car becomes apparent.

If we go up close, we shall see that rails are moving along in two never-ending lengths. Upon these the cross-ties are arranged at intervals. The whole presents somewhat the appearance of a railroad track upside down. Upon following back this tie-conveyor, we may trace it through pretty much the whole train. A conveyor constructed out of rails bolted by single bolts to angle bars, it runs over the tops of the cars and underneath the loads of ties on the tie cars. It is thus quite easy to place the ties on the novel apparatus. If we go back of the tie-cars, we see that this conveyor is continually being added to by men engaged in bolting on rails from the supply at the rear. The rails are piled lengthwise on their cars and occupy the center of the car floor. Each rail-car is provided with a "dolly" at either side. These are "amidships." There is a frame fitted with a hoist for lowering rails into the dollies. These are lowered with their forward ends depressed. Upon being bolted to the slowly-moving conveyor they become part of it.

It will be seen, then, that the rails themselves are transported to the front in such manner as to afford

METHOD OF LAYING TRACKS ON THE FLAT CARS. HARRIS TRACK-LAYING MACHINE CO.



THE NARROW-GAUGE TRAIN TRACK COMPLETE

ANOTHER VIEW OF THIS TRACK, SHOWING ROLLERS IN THE MIDDLE TO TRANSPORT RAILS

thereby a means of conveyance for the ties. Arrived at the front, the rails, as already described, are disconnected and put into the track. The moving lengths find a roller "amidships" of every car, including the tie-cars, until the foremost car is reached. Here each length finds itself gripped by a double pair of compression rollers. It is by means of these that the movement forward is secured. When the rails are disconnected just after leaving the power rollers they are not immediately delivered to the road-beds. Instead, they pass over rollers to the hoisting apparatus.

DELIVERING THE CAR WITH CROSS TIES. HARRIS TRACK-LAYING MACHINE CO.

Before the two lengths of rail forming a tie-conveyor reach the compression rollers the ties are seized by another conveyor and brought up by an incline over the top of the cantilever and down again at the forward end. This convevor consists of two endless chains provided with suitable attachments. It will thus be seen that rails and ties separate as they reach the cantilever. Of course, it is necessary to co-ordinate the three forward movements of the rails, of the chain conveyor and of the train itself.

The forward end of the cantilever is so constructed that it may be bent laterally. This is to enable track to be laid around curves. Tunnels, grades, trestles, present no difficulty to the machine. It moves on, unmindful of such variations in the work. The speed of construction is determined by the quality of the labour in front. In practice, it would seem that it is the ability of the spikers which controls. It is not necessary to put in all the spikes. Quarter-spiking is sufficient to enable the train to pass. A gang of men may then follow, completing the work. With good conditions of labour, weather, and the like, from

two to four miles per day may be laid with a single machine. A speed of eighty-four rails per hour—each side—has been attained. This is at the rate of nearly a mile in two hours. That the labour required need not be experts may readily be seen from the fact that 1,500 feet per hour has been laid by a gang having but one day's experience. There were but thirteen men at the front. There were two bolters, two nippers, four spikers, one man at the tongs, and four others.

The method of the Harris Track-laying Machine Company, of Chicago, is illustrative of an entirely distinct mode of operation from the preceding. The general appearance of the train is much different. There is the ordinary railway locomotive at the rear end. This pushes the entire train ahead every now and then. This movement amounts, upon each occasion, to about 30 or 60 feet, according to whether single or double rail-lengths are being laid at a time. Forward of the locomotive are the cars carrying the ties. In advance of these are the rail-cars. Finally, one reaches the foremost or pioneer car. At the forward end of this rails and ties are delivered to the men working at the front.

The train consists, if we except the pioneer car and the locomotive, of ordinary flat cars. Upon these a narrow-gauge tram track is laid, extending the entire length of the train. The object of this track is to furnish accommodation for the passage of a small car, upon which ties are transported to the front. On the rear cars, which transport the ties, ordinary cross-ties are arranged in such way that on each side alternate ones project. By this disposition there is the full number of ties to carry the tram track along the center of the car, while there are

LAYING THE RAILS ON THE TIES. HARRIS TRACK-LAYING MACHINE CO.

sufficient to support a footboard on either side. When the train is fully loaded the tram track is, of course, covered over with ties.

On the rail cars the arrangement of the track is somewhat different. Long timbers are arranged to support the track. Upon these, to each side of a central aisle, the rail supply is piled. The 2-foot tram track is arranged along the center, where it is sunk until it is flush with the upper faces of the cross timbers. Between the tram rails stationary rollers are arranged transversely. To get rails to the front, they are rolled or slid onto these rollers. It is then an easy matter to push them forward, notwithstanding the fact that they even weigh from 60 to 1,000 pounds or more.

To return to the tram track, however. We have explained its construction on both the rail and the tie-cars. It is apparent, however, that if a tram is to be propelled from the rear to the front the track must be continuous from car to car. Further, whatever plan of connecting up the track is adopted, it is necessary that it should be sufficiently flexible to enable curves to be rounded with facility. And, moreover, it should admit of the connecting links being readily removed. The method employed by the Harris people meets both requirements. Every rail end which it is desired to connect with another is provided with two angle bars, one bolted to each side. This forms a kind of slot. A short piece of rail, whose flanges have been cut away at both ends for a short distance, may accordinglv be readily slipped into two corresponding slots and thus connect the main rails. By this method continuity of track is easily obtained without sacrifice of flexibility. Further, the connecting pieces are readily removed, as they are not even bolted in position.

The tram car which runs in this track is propelled by hand, its crew ordinarily consisting of three men. If conditions are difficult, it may be necessary to add a fourth man. This car has two frames. To one the wheels and axles are secured. The other carries the load of ties. This latter frame is usually held in position by a latch; but when desired this latch may be disengaged, when frame and load are free to slide forward upon the roller bearings which are provided for the purpose. At the front, at the extreme end of the pioneer car, a stop-block is arranged. When the tram with its load is about to be checked by this block the latch is withdrawn, so that when the forward wheels strike the block the frame carrying the ties slides on forward. This has the effect of overbalancing the car and discharging the load. The ties are somewhat scattered to the front, and thus reach the neighbourhood of their final positions.

Having discharged its ties, the little tram is now run back over the rail cars and between the piles of rails to the supply of ties. Here it passes underneath a tie-loader, disengages a catch and receives from the loader its freight of ties. This is accomplished instantly, so that there is no delay in beginning the return trip to the front.

The tie-loader cannot be a stationary affair. As the supply of ties is more and more exhausted it must be ever at the front face of the stock. There is, however, always a track leading right up to the supply. To utilize this track, the end of the tie-loader next the pile of ties consists of a little four-wheeled truck. The forward end of the loader, on the contrary, rests on two trestles. These are provided with short runners—similar to those of a sled—which rest on the ties of the tram track, but to the outside of it. There is a double frame carried bv the trestles and the little truck. The lower one is secured directly to the trestles at one end. The other end rests on the truck. The second frame is united to the lower one by means of a number of metal links. It may thus be

raised and lowered. When lowered, its upper side is a couple of inches short of the height of the floor surface of the tram car. When raised, it is a couple of inches higher. It is maintained in this latter position, when desired, by suitable latches. It will, accordingly, be seen that the arrangements described are such as to permit the tram car to be pushed in between the two trestles back towards the little truck, provided the upper frame is in its elevated position. The truck is no more than about a foot high. There is, however, an incline running from the rear end up to about the height of the raised frame. In consequence of their arrangement, it is pretty easy to slide ties from the supply up the incline and onto the elevated portion framework of the loader. While the tram is away the men at the tie supply load this frame, which

FINISHING THE WORK BY HAND AFTER THE TRACK-LAYING MACHINE HAS PASSED. HARRIS TRACK-LAYING MACHINE CO.

has previously been secured in its raised position, so that when the tram returns there is a proper load waiting to be dumped upon it. There is thus no delay, either in loading the tram from the loader or of getting the loader ready. The dumping of the load onto the tram is accomplished automatically.

The Harris system, it will be seen, does not provide for power transportation of rails and ties to the front, but it does manage this work with a reasonable amount of labour. The management of the loader, the handling of the tram car and the transport of the rails are all effected by hand. But no one of these divisions of labour requires more than three or four men.

When the rails are pushed forward to the pioneer car they are there separated to right and left with the assistance of a steel "nose piece." As this occurs before reaching the extreme front, it is necessary to have two rollers to facilitate their passage to the roadbed. Both these rollers are arranged, however, upon a single shaft at the forward end of the car. They are depressed below the general level of the other rollers, so as to permit the descent of the rails. As a rail passes over one end of the double roller on its downward course to right or left, it is received on a portable roller called a "dolly." When far enough advanced it may be pulled transversely off the double roller. By means of the support afforded by the dolly it may then be heeled into place.

By considering the entire arrangement relative to the transport of rails, it will be seen that there has been a distinct and successful effort to minimize the lifting of these heavy loads. The rail does not have to be lifted over the tram rail, because the train track is sunk to the level of the floor. There is no lifting when on the rollers. There may be, of course, some additional effort required to push it along when on an up-grade. There would, likewise, be some additional labour involved in rounding a curve. But these are conditions that affect, perhaps, all other methods as well as this one. There is more or less gradual descent to the roadbed from the pioneer car, the necessity for lifting being carefully avoided.

The pioneer car is of special construction. From the forward truck a framework extends for about 20 feet. This is supported by rods connected with an upright frame erected at the rear of the truck. Other rods extend back from this upright and thus complete the support of the forward projecting frame. The tram track is continued on out to the front of the structure, and the double roller is suspended below its forward end. By this arrangement a clear space is obtained where work may be carried on in advance of the forward truck. This permits ties to be dumped about half a rail-length ahead of the newly-laid track. They may then be quickly put in place. The rails may be received on the dollies at a convenient point, and, after being pulled laterally off the rollers, heeled into position against the ones already placed. The rails may be passing overhead while men are arranging ties beneath.

The rails are placed in position on the ties, but are not spiked at this time. It is necessary, however, to secure them pretty rigidly in place. This is accomplished by means of bridle rods. These are metal bars bent upward at each end, the bends being at just the distance to bring the heads of the two rails to gauge when the outside flanges are against them. Sliding clamps are brought into position against the inner flanges and locked in place. All this may be quickly done. The train may then pass on. After the train has cleared the rails thus held they are permanently secured in place and the bridle rods removed. By this arrangement the progress of the track-laying is facilitated.

If it is desired to handle the work

by double-rail lengths, it may readily be done. Men must then bolt two rails to their common angle bar before they are finally delivered. Sixty-foot lengths are thus received. Correspondingly, double the number of ties must be put in place for each stage of forward movement.

If the track is being laid with broken joints—i. e., with the joint on one side corresponding with the center of the rail on the other—then the double rail on the "long side" must be run forward half a length further before it is taken from the double roller.

The weight of the rails is the formidable question in tracklaying. Whatever facilitates the management of this, especially at the front, marks a step in advance. The Harris people—whose machines have laid, perhaps, more track than those of any other concern—have developed a device for the handling of rails at the point of delivery that would seem to enhance the value of their system. At the forward end of the pioneer car a vertical frame is erected. From this project two booms, one being comparatively short, while the other is half a rail-length longer. These booms correspond to the two rails of the track to be laid. They are I-beams, and support steel carriages, from which depend rail carriers. Each carrier incloses mechanism controlling a hoisting chain. Attached to the lower end of the chain is arranged a suitable tongs for gripping a rail. When a rail is running by on the double roller this tongs is placed loosely in position. When the center of the rail bar almost reaches the jaws of the tongs a controlling lever is pulled, which has the effect of tightening them. A dog belonging to the carrier catches in the ratchet teeth of a wheel. This serves to hold the chain and put the weight of the rail on the carrier. The momentum of the running rail accordingly carries it free from the rollers. The rear end of the rail being somewhat heavier, because the grip of the tongs is ahead of the center, the rail drops somewhat at the back. As the rail swings back on the return it is lowered and the depressed end heeled into place. If the track is being laid with broken joints, the rail carried by the longer boom is run forward half a length further than the one carried by the short boom. If the joints of the track are to be even, an automatic stop is used on the longer boom, to make its effective length correspond with that of the shorter one.

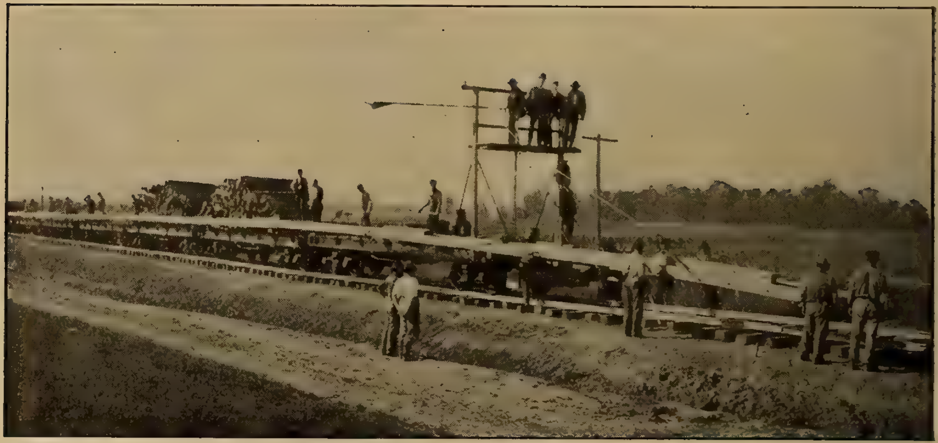
The Harris machines have been very extensively used on many American railways. Among others may be mentioned the West Shore, the Pennsylvania, the Rock Island, the Burlington, the Lake Shore, the Union Pacific, the Missouri Pacific, the Erie, etc. Three railway companies have used the Harris outfit for an average of 1,200 miles each. As to speed, one machine has laid more than three miles in one day; a mile has been laid in less than two hours, a quarter-mile in twenty-five minutes.

In proceeding by the system of the D. F. Holman Railway Track-layer Company, of Chicago, the supply train is made up of ordinary flat cars and transported to the point of activity. This train consists of a series of cars loaded with rails and ties. No especial precautions need be taken relative to the loading beyond the requirement that the rail cars shall not be loaded up to the edge on either side, and that the tie cars have a narrow space left along one side, say the right. When this train of six or eight cars, and containing a half-day's supply of material, reaches the scene of operations, it is connected with a special pioneer car.

The method of transporting rails and ties to the head of the train is by means of chutes. These are each about 30 feet in length. They are ladder-like frames in which rollers have been set transversely. The chutes used for the transportation of

the ties are about 21½ inches broad, and are fitted with cylindrical rollers about 15 inches long. The style of roller used in the rail chutes has a circular groove, and is about 12 inches in width. The rollers used in the tie chutes are more closely spaced than those in the rail chutes, because of the difference in length as between rails and ties. When in use these chutes are held in place at the sides of the cars by means of metal brackets. These are set in the ordinary stake pockets of the cars. Upon one side of the train, say the right, from the rear car to the very front, the tie chutes are arranged and flexibly connected. Upon the other side the rail chutes are set up. It is not necessary, of course, to have them extend further back than the rail cars. In these raceways the ties and rails are put and pushed to the front. Their movement is facilitated by a descending grade.

The pioneer car has a frame set up at the forward end. This carries an elevated platform. The man who controls the brakes, signals the engine at the rear and performs other duties, has his station here. This pioneer car carries miscellaneous supplies, such as spikes, angle bars, and the like. There is a metal or cable rod supported by this frame on the side of the tie chutes. This rod or cable extends obliquely forward and supports one end of a final section of the tie raceway. It is thus possible to give this chute a lateral movement, so as to make the point of tie delivery correspond with the requirements of the moment. Thus, if the work is at the time upon a trestle or bridge, the ties may be delivered at the center line. The tie raceway extends well ahead of the forward truck of the pioneer car. In fact, it reaches ahead of the rail raceway, thus permitting ties to be delivered well in advance of the rails. This arrangement serves to avoid mutual interference of the rail and tie gangs.



THE HOLMAN TRACK-LAYING OUTFIT

In accordance with the older procedure of the Holman system, the rails upon delivery are received by a rail gang. The ties and rails are put in position. The latter are partially spiked at joints, quarters and centers, when the train is permitted to advance. The completion of the work is accomplished, after the train has passed, by a gang of men working behind the engine. It is possible, however, to arrange the work somewhat differently. Thus, the "Burlington" Railroad has carried half the ties on cars to the rear of the engine. The track when first laid was only partially tied, the remainder

of the ties being put in place after the passage of the train.

The speed attainable with this system is said to be about one and one-quarter to two miles per day. Of course, much depends upon the character of the labour and the conditions involved in the work.

It will be seen that the system makes use of no power except for the advance of the train upon completion of a rail-length of track. The proof of a pudding is, however, in the eating of it. The work referred to as being done on the "Burlington" cost about $100 per mile, a gang of eighty-five men being employed. By this system 1,120 feet per hour were laid with sixty-three men on one occasion. On another, 1,111 feet per hour was put down by a force about 75 per cent. greater. It seems a little difficult to understand this, unless, in the former case, some additional men followed the train. In the latter case the track was finished by the men in front.

One of the older tracklaying systems is that of the Roberts Brothers, of Chicago. This, similarly to the Hurley procedure, brings rails and ties to the front by power-driven mechanism. Chutes are arranged on either side of the train, one for ties, the other for rails. This reminds one of the Holman arrangement. These chutes are held, however, by brackets, which fit into the stake pockets of the flat cars from below. By this means the chutes may be depressed below the floor level of the cars. This is a very advantageous arrangement, as it enables the cars to be loaded to the edge and permits transfer to the chutes without lifting. Further, no particular arrangement of the material is necessary when loading, so that cars of ties and rails, however they may have been loaded, may be incorporated into the construction train without reloading. In making up the supply train the rail cars are placed next behind the pioneer, then the locomotive and tender, and finally the tie cars. The line of rail chutes is thus quite short.

ANOTHER VIEW OF THE HOLMAN TRACK-LAYING APPARATUS

That of tie chutes, on the contrary, is long, and extends back past the locomotive. The chutes are hinge-connected between cars and contain sets of live rollers. These are operated by shafts of equal lengths with the chutes, and have angle or universal couplings to secure the transmission of motion. These two lines of semi-flexible shafting are operated by driving mechanism mounted on the pioneer car, the steam for whose engine is supplied from the boiler of the locomotive. This arrangement as to steam is, perhaps, the controlling reason for the make-up of the supply train, with the locomotive just back of the rail cars instead of at the far rear. The live rollers in the tie chutes alternate with dead rollers, whose upper surfaces are at a lower level. Otherwise, the irregularities in the contacting surface of a tie might easily remove the tie from efficient contact with the live rollers.

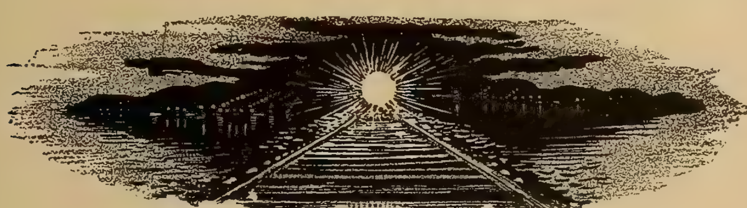
LAYING THE CROSS TIES AHEAD OF THE PIONEER CAR. THE HOLMAN TRACK-LAYER CO.

By simply dropping the ties in the chutes alongside, they fall into what is practically a conveyor, and so are carried forward to the front. Upon the other side of the train the rails are likewise dropped or rolled into their chutes, where they receive a constant impulse forward from the live rollers. The two lines of shafting are operated independently, but are under the control of a single engineman. The tie "conveyor" is continued for about 60 feet forward of the pioneer car. The delivery of the rails is likewise in advance, but only about 6 feet. The men handling the ties are thus distinctly ahead of the rail men, even after allowance is made for the length of a rail. This is, of course, an advantageous arrangement, as it avoids interference between the two gangs. A vertical frame suitably held in position on the pioneer car affords points of attachment for the supports for the two

extension chutes. Both these latter are depressed forward, thus utilizing gravitation at the moment of delivery and bringing the material to convenient levels. The rollers of the terminal rail chutes are each in two sections, both halves rotating on the same axle. This arrangement permits a somewhat independent handling of two rails delivered at about the same time. A support on the rail side is rigged to the vertical frame, which enables the forward end of the rail to be kept somewhat elevated while heeling into place is accomplished.

This system has been long in use. Many railroads, including the Great Northern, the Northern Pacific, the Canadian Pacific and the Union Pacific, have employed it in track construction. Two and three-quarter miles per day is said to have been averaged with this apparatus for a distance of 109 miles on a branch line of the Chicago & Northwestern Railway.

In conclusion, it may be stated that no one of the various apparatus described is an experiment. They have, one and all, been thoroughly tried out. They are successful devices. The Harris, Holman and Roberts machines have been used not only in the United States, but in Canada as well. And the Harris and Holman apparatus have likewise been employed in Mexico. Nor are we to regard these machines as adapted merely to special conditions. The character of the finished track does not depend upon the tracklaying device, but upon the quality of the labour and superintendence responsible for the final fixing in place of the material. In other words, these devices are handling appliances. And the quality of the track no more depends upon them than the excellence of a bridge pier depends upon the kind of wagons that convey the stone.



Current Topics

THE growth in the size of ships has for hundreds of years borne severely on one port after another. One reads of the decay of occasional places like Winchelsea because the sea has actually left them. Winchelsea Bay was filled up with shingle by the sea itself. There was no dredging in the old days to maintain depths. To-day, if a port is threatened by reason of its insufficient depth, it proceeds to dredge while trade yet remains to pay for the work. Liverpool has an immense trade, and has, therefore, been able to call to its aid the most powerful machinery in keeping sufficient water over its bar. But large ships are restricted to quite a few ports round the coast, and depths of nearly 50 feet are talked of in connection with the latest proposals for accommodating the biggest ships at Plymouth.

It is realized that the Suez Canal was a great influence in keeping ships of moderate draught. This was simply because the canal afforded such economies that it could impress limitations on ship draughts. But on the Atlantic route there are no such limitations. One port or another will deepen itself for a long time to come in order to keep the ships. But some of our ship channels are becoming close fits for the bigger vessels, and if the depth of ships continues to increase as it has done there will be some interesting problems in dredging and dock engineering before long. The papers by Professor Haupt in this magazine for this month and last show the situation at Liverpool and at New York, and these are but two ports out of many.

THERE has been much talk of late about the enormously increasing cost of national administrations, and both in England and the United States the necessity for providing increased revenues appears to be urgent. The method of the statesman for raising revenue is that of taxation, either direct or indirect; that is, he collects the money from those who have already acquired it. It can hardly be expected that a government should go into business on its own account to realize the money required for its expenses, but it may be well to consider what can be done to add to the new wealth of a country instead of diverting existing wealth from industrial purposes.

The extent to which the scientist and the engineer have added to the wealth of the world is not always appreciated. Thus, when the victorious Prussians imposed upon France, in 1871, a war indemnity of five milliards of francs, financiers and statesmen stood aghast, scarcely con-

ceiving how such a sum could be raised. Within a few years, however, new wealth to even a greater amount had been produced in France solely by the work of Pasteur in preventing the losses due to the phylloxera. The real source of this wealth was the reduction of waste. More than two generations before there had been made a like addition to national wealth in America by Eli Whitney, whose invention of the cotton gin so reduced the waste in preparing cotton as to increase enormously the wealth-producing capacity of the entire group of Southern States. In like manner, the work of the engineer in the development of agricultural machinery, of modern methods of mining, metallurgy and transportation has resulted in the production of new wealth—wealth which would otherwise not have existed or would have remained for centuries in latent form.

In view of such considerations there is an almost ludicrous element in the spectacle of a body of government officials solemnly gathering in a special manner to impress upon the scientific, commercial and technical world the desirability of conserving national resources. There is probably no more wasteful body of men in existence than such a gathering of politicians; and yet these men, of all others, entirely lacking in the slightest sense of humour, have proceeded to tell the engineering profession—the men who have given to the world the most efficient and productive processes and devices in existence—that they are wasting the national resources!

That there are many wastes yet to be remedied no one is more ready to admit than the engineer; but when it is remembered that during the past fifty years he has trebled the efficiency of the steam engine, doubled the efficiency of the internal-combustion motor, and made similar increases in the efficiencies of workmen and machine tools, that his combustion engines show an efficiency of 40 per cent., his turbines an efficiency of 80 per cent., and his dynamos and motors of nearly 90 per cent., it seems as if the statesmen might well look nearer home in their search for opportunities for minimizing wastes.

PROFESSOR CARUS WILSON, in his recent paper on rail corrugation, appears to have given much study to the matter. Briefly, as we read his paper, corrugations are due to the torsional stress in the axle set up by the differential running of the wheels upon rails of different length, as round a curve. One wheel should, on a clear rail, slip steadily; but if there is grit or dirt on the rail, the wheel will slip intermittently. The argument is well sustained, and we are very much inclined to think that the professor is right. We have long thought that the axle torsion was connected with the cause. Grit on the rail seems to be another factor. Probably short trucks are a predisposing factor also, for they help to force the flanges of the wheels across the track. No wheel base ought to be so short as the gauge of the rails, and it would be well to aim at a minimum of 6 feet for standard gauge trucks.

Obviously there is small hope of curing this vice of corrugation so long as axles are solid, and the loose wheel has never found favour. Indeed, it is useless on a driving axle.

THERE is a right and a wrong way to influence legislation, and, as in other cases, the right way usually wins out in the end. In the United States, the Railway Business Association is making its influence felt by various Legislatures by the simple and direct method of stating plainly just what seems to be right, coming out publicly and openly in an entirely reasonable manner, thus following the methods which engineers are in the habit of employing in the technical portion of their work.

CHARLES B. RICHARDS

Professor of Mechanical Engineering in Yale University

A BIOGRAPHICAL SKETCH

IT is especially appropriate at this time to place upon record some of the salient features of the career of Professor Charles Brinckerhoff Richards, since his retirement from active duties at Yale calls attention to the fact that he represents the development of technical education in the United States.

Born at Brooklyn in 1833, Professor Richards was educated at private schools in Long Island and in New Jersey, and because of his evident taste for mechanical and scientific subjects it was desired to give him a technical education. At that time, however, there was no college in the United States in which mechanical engineering was made a specialty, and so, at the age of eighteen, young Richards entered the shops of Woodruff & Beach, at Hartford, Conn., where, under the able superintendence of William Wright, there was ample opportunity for the acquisition of a practical training in the design and construction of heavy machinery, steam engines, etc. An engagement of three years in the Colt's Armory at Hartford followed the apprenticeship in the Woodruff & Beach shops. For one year after this Mr. Richards was foreman in the establishment of James O. Morse, in New York City, engaged in the manufacture of valves and pipe-fittings and in the execution of contracts for warming and ventilating buildings, and in 1859 he opened an office in New York as a consulting and designing engineer and solicitor of patents.

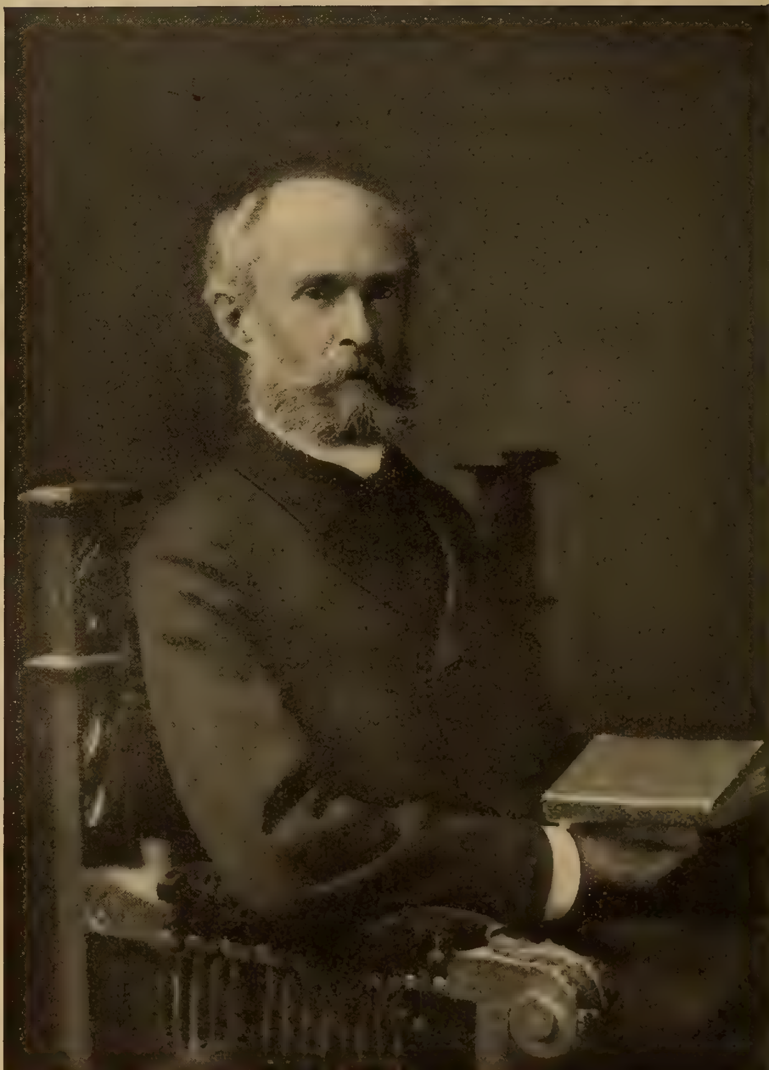
It was during this period of his career that Mr. Richards produced his parallel-motion indicator, an instrument which almost immediately superseded the older indicator of MacNaught and made the subsequent great improvements in the steam engine possible.

In 1861 Mr. Richards was recalled to the Colt's Armory as engineer-superintendent, where he remained for nineteen years, thus practically guiding its work through the period of intense activity occasioned by the Civil War, and later in the execution of great contracts for pistols, rifles and machine-guns for the United States and foreign governments.

In 1880 he went to the Southwark Foundry & Machine Company, to join his old friend, Mr. Charles T. Porter, in the manufacture of the Porter-Allen high-speed engine, and after four years spent in building large engines for pumping, blowing, rolling-mill work, etc., he accepted, in 1884, a call to the chair of mechanical engineering at Yale, which he has occupied for twenty-five years, retiring this year.

It is hardly possible to conceive a better preparation for the work of instruction in mechanical engineering than has been outlined above, and it is interesting to note that Professor Richards himself thus filled the gap which existed at the time when, as a young man, he himself sought just such instruction.

Professor Richards was one of the founders of the American Society of Mechanical Engineers, and served as manager in 1880-1882 and vice-president in 1888-1890; he is a Fellow of the American Association for the Advancement of Science, member of the Connecticut Academy of Sciences, of the Society of Naval Architects and Marine Engineers, and of the Société Industrielle de Mulhouse; United States Commissioner to the Paris Exposition of 1889, and Chevalier of the Legion of Honor of France.



LEWIS M. HAUPT

See page 287.

CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

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RECENT DEVELOPMENTS IN LARGE GAS-ENGINE DESIGN

By Percy R. Allen

1. THE FOUR-CYCLE ENGINE—BRITISH AND CONTINENTAL PRACTICE

In the series of articles of which this is the first, the development of the large gas engine will be set forth in a manner which amply sustains the predictions which have been made in these pages during the past two years. The present paper discusses the four-cycle gas engine in British and Continental practice, and it will be followed by an article describing American developments, and by a third paper upon large two-cycle engines.—THE EDITOR.

THE position of the large gas engine up to eighteen months ago was so well covered by the information given in the special Gas Power Number of CASSIER'S MAGAZINE, published in November, 1907, that the present articles may be best regarded as simply a continuation of the subject up to date.

None of the prominent makers have materially changed the design during this period, and many of the writer's friends abroad state that they have nothing to add to the already published descriptions of their design, and from the engine-builder's point of view the progress to be recorded during the past eighteen months has been chiefly in the direction of building larger units, in seeking greater simplicity of design, and in one or two cases in the development of the vertical gas engine of large capacity.

The fact that several of the engineers connected with the best-known power schemes have begun to consider carefully the possibilities of gas engines for central stations is an encouraging feature, and the successful introduction of producer plants and gas engines into the cotton manufacturing districts suggests that there will shortly be a large field for gas engines where steam has been hitherto considered unassailable.

It is difficult to say when a gas engine becomes a large gas engine. A few years ago 300 horse-power was considered the starting point, then 500 horse-power, and now, in a recent article published in the *Zeitschrift des Vereines Deutscher Ingenieure,* a thousand horse-power seems to be taken as the minimum. The list gives the name of twenty-eight makers, nineteen on the Continent, four in England and five in the United States. Altogether, it adds up to a total of 628 engines, giving a combined output of 1,035,709, or more than one million horse-power in large units. The Nürnberg Company heads the list with 129 engines, equal to 203,870 horse-power; but very rapid progress has been made in the United States during the last year or two. These figures are of value if they only help to remove an impression which seems

to have got abroad that the large gas engine has met with a setback, due to the introduction of the exhaust steam turbine and the Rateau accumulator; but, as a matter of fact, their applications do not overlap at all, and a distinction should be drawn between waste heat in the form of surplus steam and combustible gases going to waste.

An exhaust steam turbine applied to a colliery winding engine or a rolling mill engine may be a means of utilizing a considerable amount of wasted power for a comparatively small capital outlay, and in a steelworks a good deal of steam can be often obtained from boilers over reheating furnaces, which power could not be utilized in internal-combustion engines, and in such cases the low-pressure or mixed steam turbine comes in as a valuable adjunct to an existing power plant; but the moment it becomes a matter of dealing with the unburnt gases one is met with the indisputable fact that from two to three times more power can be obtained by using the gas directly in the gas engine than by burning it under any form of steam boiler.

Various authorities have conducted close experiments, and in all cases an economy of more than 2 to 1 has been realized; and the writer himself had several years' experience, which enabled him to compare the consumption of gas when burned under boilers and when utilized in gas engines. It has become the fashion to say that capital charges are invariably the controlling factor in the cost of electricity; but where there is a high load-factor, as there must be when the gas derived from coke ovens or blast furnaces is utilized, the capital charges on a gas-driven plant compare by no means unfavourably with a steam turbine plant. The subject is discussed in a very interesting brochure recently published by Messrs. Haniel & Lueg entitled "The Comparative Efficiency of Gas Engines and Steam Turbines." Two cases are dealt with, one using blast-furnace gas and the other coke-oven gas. In the first instance it is assumed that two blast furnaces, each having a daily output of 200 tons, are relied upon to supply the gas. These would give sufficient surplus gas to generate continuously 6,624 kilowatts, providing efficient gas engines were put down and the capital outlay on this plant, including buildings and cleaning plant and 50 per cent. of spare power, is taken as being £80,500, or equal to £12.15 per kilowatt; and, allowing 15 per cent. for interest and amortization, the running costs come out to .068*d*. per kilowatt-hour. For the steam turbine installation the same amount of gas is supposed to be available; but being burned under boilers this produces only half the power, and the turbine plant represents only 3,312 kilowatts. The cost of this installation is calculated to be £48,786, or £14.7 per kilowatt installed. Allowing 15 per cent., as before, for amortization, the running expenses of the steam plant come out to .085*d*. per kilowatt-hour, which is 20 per cent. more than the gas engine case. This shows a clearly direct saving of £4,236; but if it is taken into account that the gas plant gives double the output for the same amount of gas, the saving becomes very much greater, and this is a point generally ignored by engineers who advocate gas being burned under boilers and using steam turbines.

The comparison with coke-oven gas is on much the same lines, but examples of two rather smaller plants are taken. In the gas plant the installation is taken as 3,700 kilowatts and the steam plant 1,895 kilowatts. Capital expenditure works out for the gas plant £10.55 per kilowatt and for the steam plant £15.6, and the running expenses under the same conditions as before are, respectively, .064 and .093. These figures, of course, are based on a load factor of between 80 and 100 per cent., and in an ordinary central station the con-

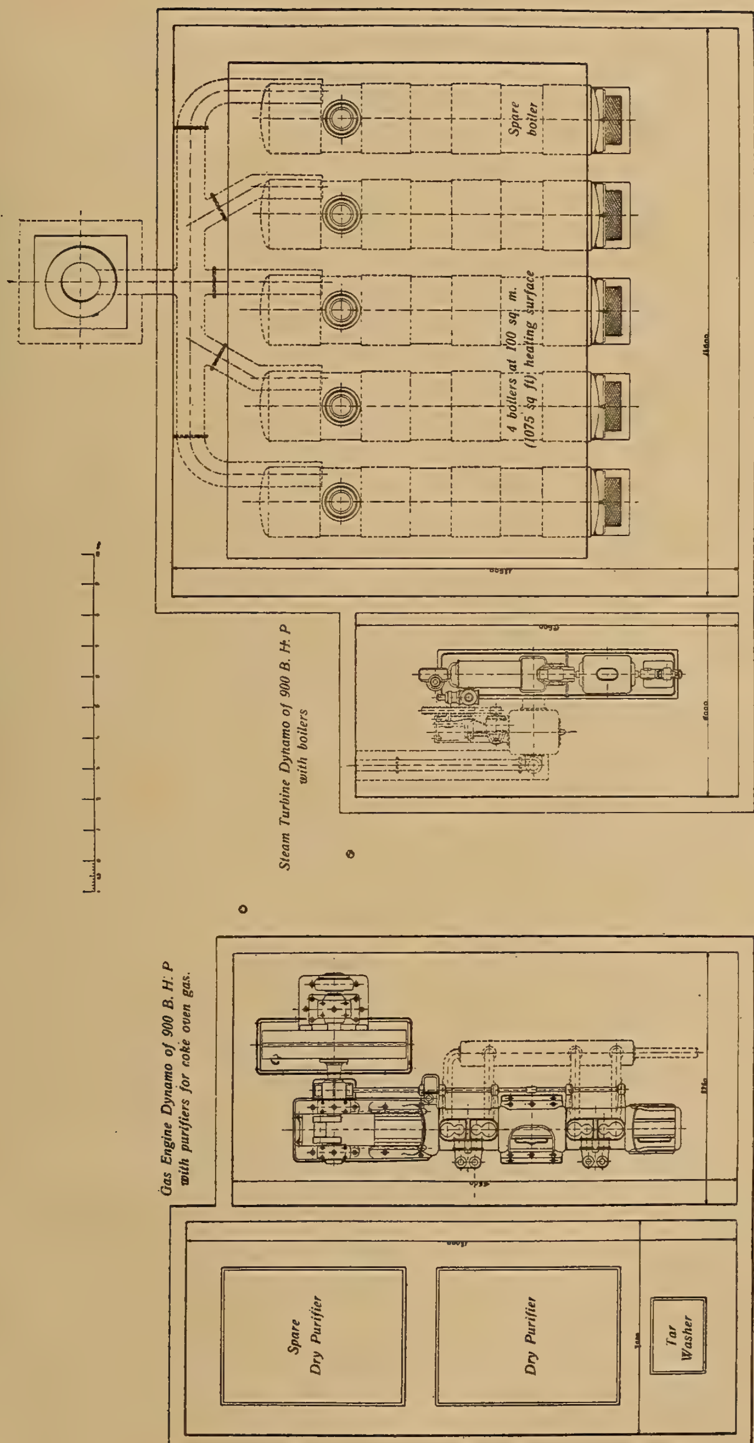


FIG. 1.—RELATIVE SPACE OCCUPIED BY GAS ENGINE AND TURBINE

ditions would be very different.

To form a correct view of the matter a great many things would have to be taken into consideration, and the subject had better be studied by reference to the papers of Messrs. Andrews and Porter read before the Institution of Electrical Engineers, and a paper of Mr. C. H. Merz, read before the Iron and Steel Institute in 1908, and the Haniel & Lueg pamphlet, already referred to. The illustration reproduced from this brochure shows the comparative space occupied by gas engines with the accessory cleaning plant and a steam turbine with the necessary boilers and condensers of equal output.

Coming now to the constructive features of large modern gas engines, as at present built, they may be roughly divided into two types, one operating on the well-known Otto four-stroke cycle and the other on the two-stroke cycle, as in the Oechelhäuser or so-called Körting cycle. The Otto type engines are constructed either with single-acting cylinders, open at one end and having trunk pistons, or with double-acting closed cylinders; and either a single cylinder may be used or two cylinders may be placed either side by side or tandem, one behind the other, or a combination of four cylinders may be arranged twin-tandem.

As the Otto cycle consists of one power-stroke in four, it will be seen that a twin-tandem, double-acting gas engine has the same number of impulses as a twin steam engine.

The writer is not aware of any firms now building Otto cycle engines of above 1,000 horse-power who still adhere to the open-trunk, single-acting design, and there is no reason why they should do so, as the stuffing-box difficulties have long been overcome; and in most large double-acting engines it is almost as easy to examine the piston and interior of the cylinder as it is to withdraw the trunk from the single-acting arrangement.

Some of the makers on the Continent build both Otto-cycle and two-cycle engines, and while there seems to be a strong tendency to develop the two-cycle arrangement, the majority of large engines so far constructed have been built on the four-cycle system; and such engines, with one, two, three or four double-acting cylinders, arranged singly or tandem, or as a twin engine or twin-tandem engine, are built by quite a number of makers.

Although each individual builder has introduced some modification of his own, there is a strong family likeness, and it has become customary to refer to the design generally as being of the "Nürnberg" type.

The John Cockerill Company, of Seraing, Belgium, who were one of the early firms to embark on the building of large gas engines, have adopted a rather different method of construction, chiefly in the arrangement of the frame and in the construction of the cylinders, while the American double-acting Otto engine has further points of difference.

The general construction of an engine of the Nürnberg type will be readily understood from the following illustrations, Fig. 2 showing a longitudinal section of a tandem engine. The front frame carries two bearings for the double-throw crank, which is almost universal in Continental practice. The bottom of this frame also forms the guide to the front crosshead, while the rear of the casting is made cylindrical and carries the front end of the first cylinder. The back end of this cylinder and the front end of the second cylinder are carried by an intermediate distance piece, which has feet on each side bridging the pit between the cylinders, and the back end of the second cylinder is supported by a circular flange on the rear guide piece on which the back crosshead works. The distance piece between the two cylinders serves as the guide for the intermediate crosshead. The front frame is anchored to an ade-

quate mass of foundation, and the rest of the engine is capable of a certain amount of end movement to allow for expansion. It is now the usual practice to cast the cylinders with the inner and outer walls in one casting, with the connections for the inlet valves on the top and the exhaust valves directly opposite them at the bottom. Ample space for water-cooling is provided between the inner and outer shells, with plenty of handholes for cleaning and inspection. A general view of one of these cylinders, 41½ inches diameter, belonging to a Haniel & Lueg engine, is shown in Fig. 3. The inner circle of studs serves to bolt the cylinder covers to the ends, while those in the outer circle hold the cylinder to the bed-frame and supporting pieces; and it has been found necessary in practice to make these studs with a fine thread and not with Whitworth threads, which become loose. The intermediate distance piece, supporting the two cylinders in a tandem engine, is shown in Fig. 4. It will be seen to be well ribbed longitudinally, and although there is a large opening at the side to get at the pistons when withdrawn, the removal of this metal is compensated for by the introduction of stiff stay bolts.

In the engines built from the Nürnberg company's own design, the front bed also has stay bolts extending from the portion of the casting supporting the cylinder to near the main bearing; but in other cases these front stays are dispensed with and the beds made rather deeper. The tandem pistons are carried by two rods, which are interchangeable with one another, and are united at the middle slipper guide, this arrangement being illustrated in Fig. 5. This middle slipper guide serves also as a point for the introduction of the cooling water to the hollow piston rods and to the interior of the piston, the water entering under pressure through a system of vibrating rods and after having passed through the pistons is discharged through suitable vents at the front and rear crosshead blocks. Some few makers still use the sliding tube or trombone device for supplying the pistons with water.

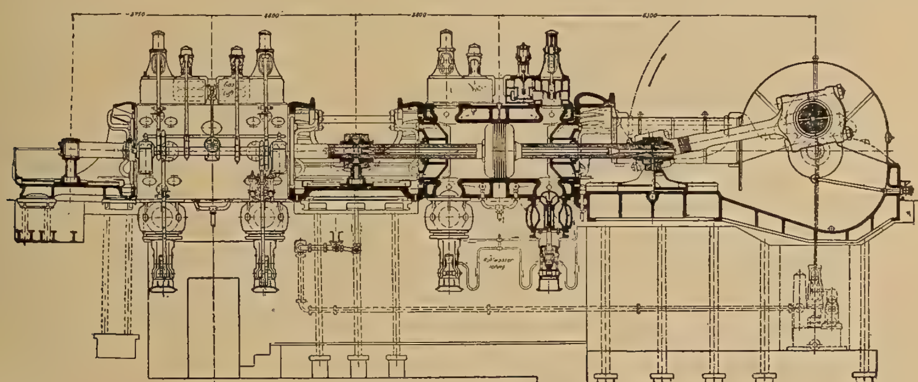


FIG. 2.—LONGITUDINAL SECTION OF A NÜRNBERG TANDEM ENGINE

The usual practice is to make the piston rods of 3 to 4 per cent. nickel, mixture steel and to bore the holes out of the solid, and in the example of Messrs. Haniel & Lueg's shown in the illustration, Fig. 5, the rods are turned with a slight camber, so that when at work the piston floats in the cylinders, the only friction being that from the piston rings. Where the valve inlets and outlets are cast in the cylinder, as in Fig. 3, the cylinder covers resolve themselves into

very simple symmetrical castings; and as these are of smaller diameter than the distance between any portion of the frame, they can readily be slipped along the rod to give access to the interior of the cylinder.

Metallic stuffing-boxes are generally sunk in the heads, to get the benefit of water-cooling; and, considering the work they have to do, they give singularly little trouble. Indeed, on the Continent the trouble from broken heads, cracked cylinders and defects in pistons may be considered as completely overcome; but this has only been arrived at by successive modification of design and by very careful attention in the foundry. At the works of the Gasmotoren Fabrik Deutz, near Cologne, very delicate instruments are used to investigate the expansions and stresses between the inner and outer walls of the cylinders under different conditions; and the writer recently saw at Messrs. Ehrhardt & Sehmer's foundry at Saarbrucken elaborate precautions taken to ensure good cylinder castings, both by chemical analysis of the material and by physical tests of the actual metal taken from every pouring. It may be considered that, theoretically, the inner tube of the cylinder should be free to expand independently of the outer casing; but in practice casting the inner and outer walls together seems to answer perfectly well, providing the ribbing is judiciously arranged and the water space is made large enough. Most of the Continental builders of the Nürnberg type adopt this plan, although the John Cockerill Company use a rather different design. In Fig. 6 it will be seen that the cylinder covers are held through bolts passing through the water jacket. The portion of the cylinder ends through which the stresses are transmitted is a very small one and comes quite close to the outer casing, which is recessed in the side frames, these forming a continuous structure from end to end of the engine.

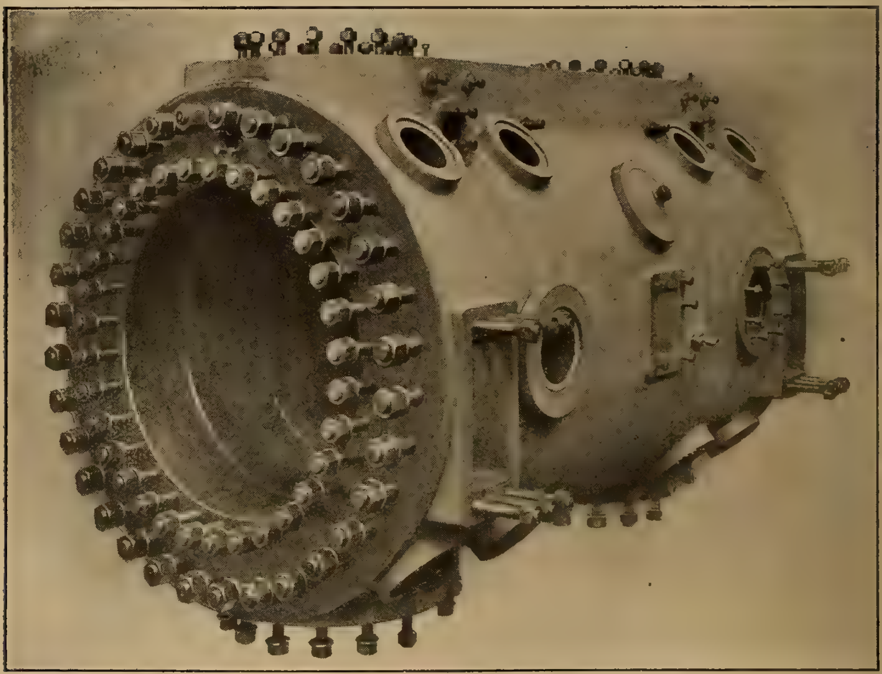


FIG. 3.—GENERAL ARRANGEMENT OF GAS-ENGINE CYLINDER. MESSRS. HANIEL & LUEG, DUSSELDORF, GERMANY

The pistons of large four-cycle gas engines are now generally made in the form of short drums with slightly convex ends. Sometimes the pistons are made in two pieces, which are bolted together against a collar forged on the rod; but more often they are constructed as a simple hollow casting, which is drawn up against the shoulder on one end by a nut on the other, this nut being countersunk, so that when in position it presents no surfaces with projections to remain hot and cause pre-ignitions; neither are there any recesses to retain the smouldering gases.

Care should be taken with the pipes distributing the water in the interior of the pistons, otherwise they get broken off and proper circulation on the walls of the piston does not take place. Where the rods are properly cambered, the body of the piston hardly touches the walls of the cylinder, and if proper arrangements are made for lubrication the wear is exceedingly small.

Coming now to the valve gear of gas engines and the methods of distributing and governing the supply of mixture, it will be found at once that the conditions are much more complicated than in the case of the steam engine, in which the steam may be considered as a homogeneous mixture. Neglecting the question of cylinder condensation, the only variable quantities in a steam engine are the temperature and the pressure; but in a gas engine the calorific value of the gas supplied to the engine may vary considerably from hour to hour, perhaps as much as 10 per cent.; and while in a steam engine the moment the ports are opened the steam is admitted under pressure and fills the cylinder up to the piston, in a four-cycle gas engine the proper mixture is obtained only by drawing in simultaneously the necessary proportion of gas and air, and even after the mixture has been obtained it has to be ignited at exactly the proper time and under the best conditions to obtain the intended results.

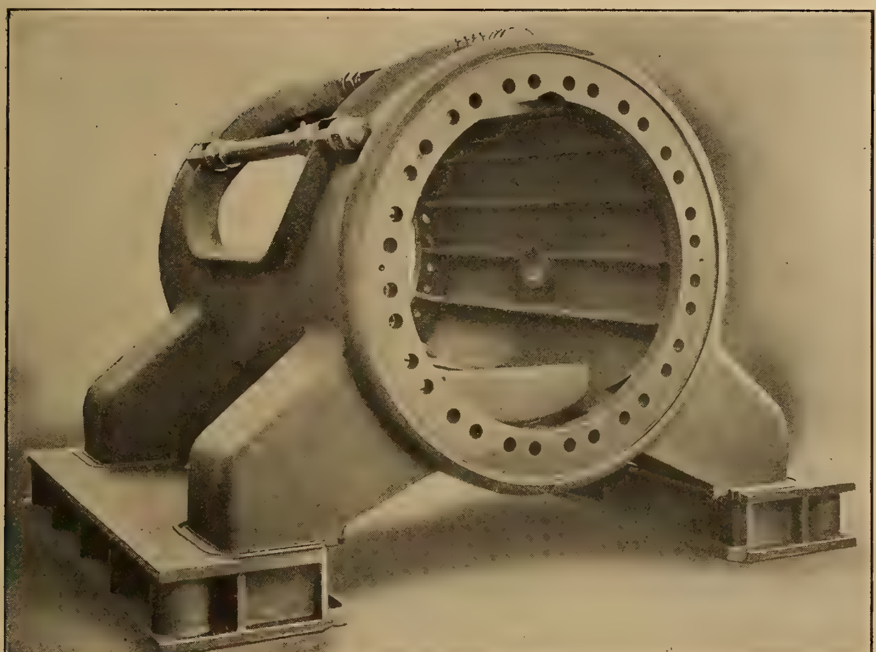


FIG. 4.—INTERMEDIATE CONNECTING PIECE ON HANIEL & LUEG TANDEM ENGINE

Moreover, in some cases it is desirable to take advantage of the fact that air and gas can exist in stratified layers, and in other cases an intimate mixture must be obtained. Altogether, the formation and distribution of mixture in a gas engine are quite complex subjects and can be only touched here. In most engines the air and gas are generally conducted in separate ducts up to the mixing valves, and hand-operated valves are provided in these ducts to adjust roughly the proportions of air and gas, so as to bring them within the control of the mechanically-operated mixing valve, and thus within the influence of the governor. The function of the governor is to control the total amount of gas and in some cases the timing of the ignition is controlled by the governor at the same time it varies the supply of gas. Reichenbach employs in his engines a combination of quantity, quality and ignition governing.

Quality governing gives a constant compression, whereas quantity governing at low loads may involve a heavy suction towards the end of the explosion stroke; but against this must be set off the fact that with quantity governing the charge to be fired may be kept always of the same richness, whereas with quality governing the mixture may be so impoverished that it is difficult to fire.

Quality governing may be effected in two ways, either by opening the gas valve simultaneously with the in-

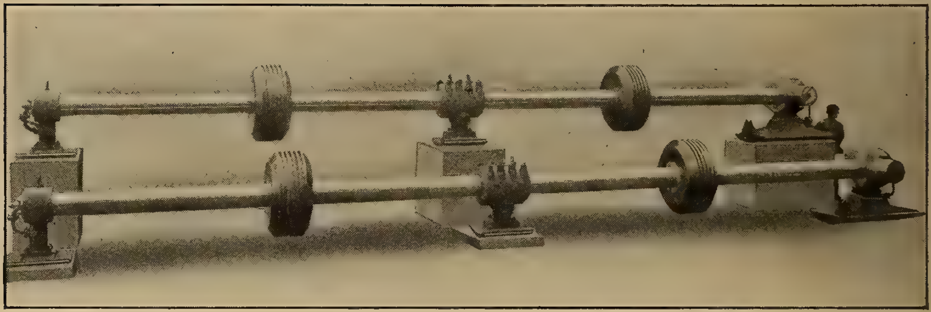


FIG. 5.—PISTON ROD WITH PISTONS AND SLIPPERS FOR TANDEM ENGINE

admitted to the cylinder each stroke, however it may actually effect this, and there are four systems practically employed on four-cycle engines. First, the hit-and-miss, in which one or more explosion strokes are from time to time omitted as the engine seeks to increase in speed. This is an economical but unsteady arrangement, and is not used in large engines. Secondly, quality governing, in which the volume of the mixture is kept constant and the proportion of gas to air automatically varied. Thirdly, quantity governing, in which the strength of the mixture is kept constant, but the amount admitted each stroke is varied; and fourthly, a combination of quantity and quality governing, let valve and by tripping the valve and shutting off the supply sooner or later in the suction stroke as may be directed by the governor, or exactly the reverse may be done, the air being admitted first and the gas valve only allowed to be opened after the suction stroke is more or less completed. In this case the gas valve shuts approximately simultaneously with the inlet valve, the idea being that in this case the gas and air remain more or less stratified and a rich, easily combustible part of the mixture is always presented to the igniters, even at low load. However, both systems seem to work equally well, and in some experiments the writer has made with glass models and coloured smoke the mix-

ture at the end of the compression stroke seemed to be equally homogeneous in both cases.

Cast-iron mitre valves that open inwards are generally used both for inlet and exhaust valves, and various forms of mixing or regulating valves are employed, some makers placing them above and concentric with the inlet valves themselves; but they are usually placed in a separate chamber alongside the inlet valves proper.

On four-cycle engines the valve gearing is usually worked from a lay-shaft driven by skew gearing on the crankshaft, the two-to-one reduction necessary for operating the valve on the Otto cycle taking place either directly at the crankshaft or by means of spur gearing just in front of the first cylinder in a tandem engine, the object of this being to prevent jerking or ringing by keeping the slow-running shaft as short as possible.

The governor is generally driven somewhere off the lay-shaft and controls the gas mixing-valves by releasing them in much the same way as drop valves are tripped on a steam engine. The valves themselves are worked either by cams on the lay-shaft and bell-crank levers, or by eccentrics acting through rolling levers. The eccentric arrangement works very smoothly; but, as is well understood, the fulcrums of the rolling levers must be carefully watched in case of any wear, as loss of motion in these parts alters the whole timing of the valve.

Compressed air, at a pressure of from 150 to 250 pounds to the square inch, is now almost universally used for starting, the starting valves being driven in some way from the lay-shaft. In twin or tandem engines the starting gear is so arranged that the compressed air is admitted to one cylinder only, and the gear can be put out of operation as soon as the other cylinder begins to fire and take up the load.

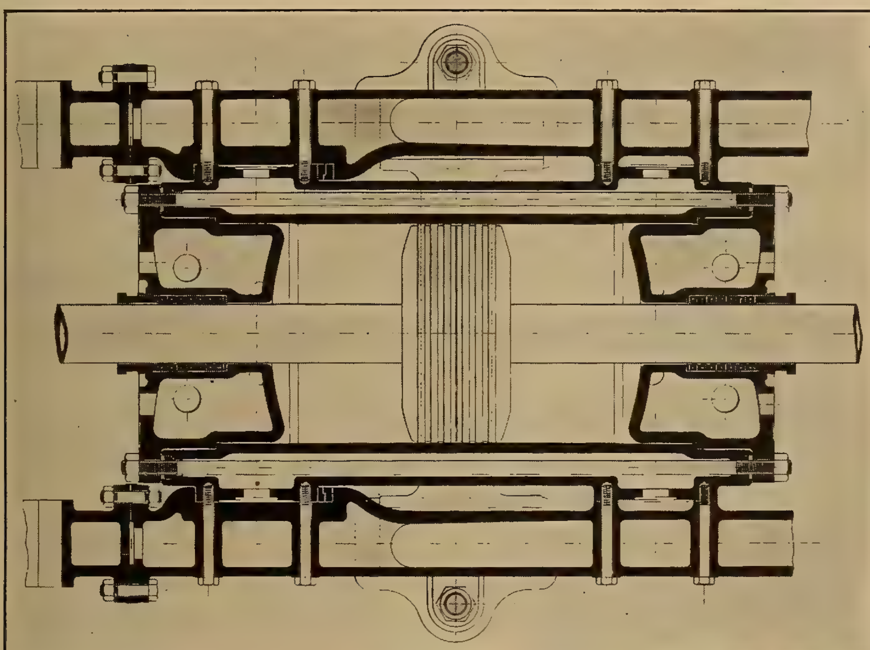


FIG. 6.—SECTIONAL VIEW OF GAS-ENGINE CYLINDER. JOHN COCKERILL COMPANY, BELGIUM

There are several systems of igni-

tion favoured by various makers. The low-tension Borsch magneto arrangement seems to be perfectly satisfactory as long as the contact tongues do not get damp while the engine is standing. Several firms use a make-and-break arrangement similar to the Borsch, but indirectly acted on by means of a solenoid receiving current from some external source, generally accumulators, the timing being effected by means of a kind of slip-ring with a rotating contact, which completes the circuit to each solenoid at the proper time. Advantage is taken of the extra current from the solenoid to intensify the spark. Proper provision is made to advance or retard the spark by shifting the brushes. In the Lahmeyer arrangement a true arc is formed every time the contacts break.

Lodge high-tension ignition is successfully used in some cases and well spoken of.

About ten gallons of water per brake-horse-power-hour is required to be circulated through the piston at a pressure of from 35 to 40 pounds, and this supply is generally obtained from a small, independent pump worked off the crankshaft.

The water supply for cooling the cylinders may be derived from a tank arranged at any suitable height to give a good flow to the connections, and the plan of bringing all the discharges to a group of tun dishes, which is very common on the Continent, is a convenient arrangement, as it enables any cessation of flow to be at once noticed by the attendant.

The lubrication of the cylinders and stuffing boxes is almost universally provided for by screw-down pumps of the Mollerup pattern, and in the best practice a separate pump is provided for each individual oil pipe.

The foregoing description of a large horizontal four-cycle engine applies in a general way to the engines built by the Augsburg & Nürnberg Company and by their direct licensees, and also to designs of Messrs. Haniel & Lueg, the Gutehoffnungshütte Company, Ehrhardt & Sehmer, Thyssen & Co., Schuchtermann & Kremer, of Dortmund; the Deutz Company, of Cologne; Körting Bros., of Hannover, and several other firms, who are, perhaps, not so prominent.

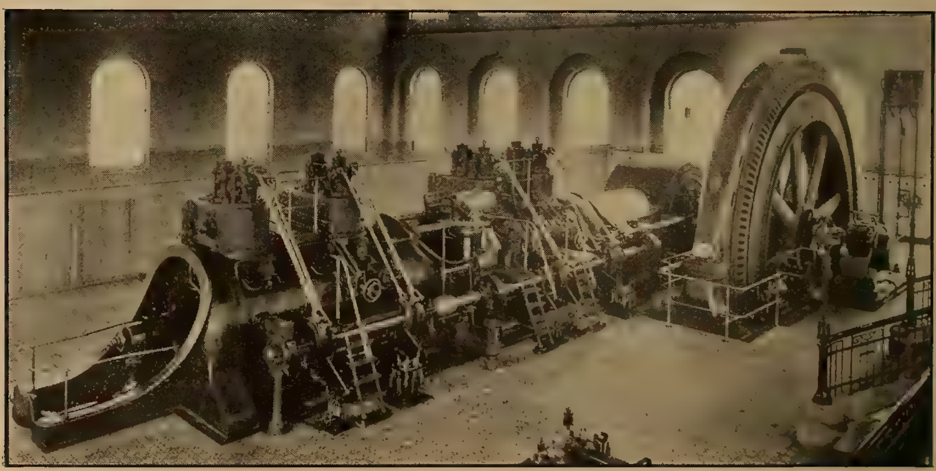


FIG. 7.—TANDEM FOUR-CYCLE ENGINE BY THE GUTEHOFFNUNGSHÜTTE COMPANY, STERKRADE

Fig. 8 shows one of the latest types of Haniel & Lueg's engine, of which the component parts have been illustrated in Figs. 3, 4 and 5. Quite a number of engines of this construction are to be met with in Westphalia and Luxemburg.

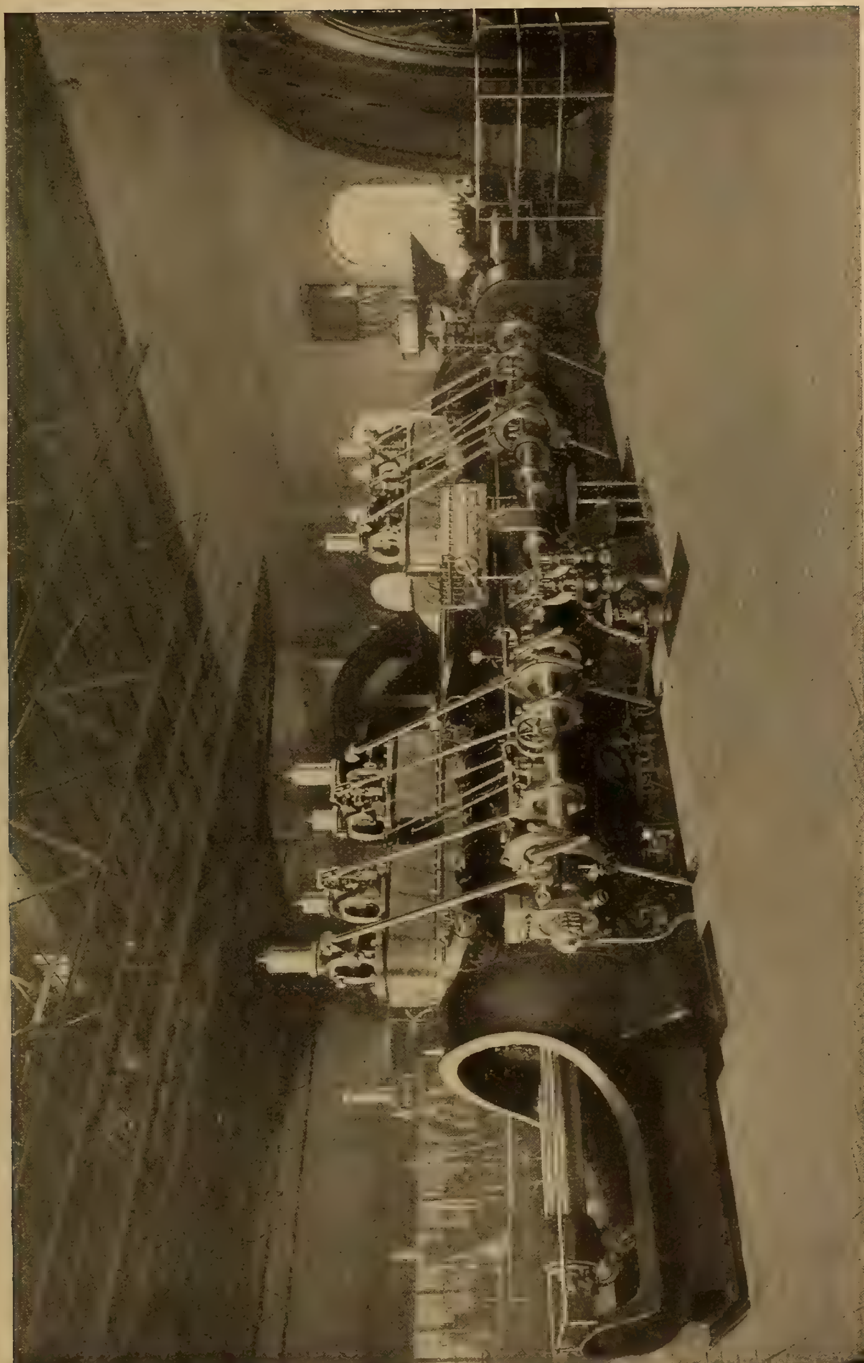


FIG. 8.—FOUR GAS ENGINES, OF 1,600-HORSEPOWER EACH, DRIVING ALTERNATING-CURRENT DYNAMOS. GUTEHOFFNUNGSHÜTTE SMELTING WORKS, OBERHAUSEN. HANIEL & LUEG, DUSSELDORF, GERMANY

In England the Lilleshall Company have supplied to the Barrow Steelworks the first engine built in England according to purely Nürnberg designs, and an illustration of this is given in Fig. 10. The engine develops 1,100 brake-horse-power, and it is direct coupled to a blowing tub 85⅝ inches in diameter, which compresses 26,000 cubic feet of air per minute at 8 pounds pressure. The diameter of the gas cylinder is 35 inches and the stroke 43¼ inches, and the engines make 90 revolutions per minute.

The Barrow Steel Company have also installed at their works some large four-cycle engines built at the Sterkrade works of the Gutehoffnungshütte Company. These are of the type shown in Fig. 7—at least the engine is of the same type, although the illustration is one of a plant actually at work at the Gutehoffnungshütte Company's own works. This particular photograph shows the particulars of an engine of this kind very clearly.

Fig. 9 is a view of a portion of the power house at the Anna pit of the Eschweiler Mining Company, at Alsdorf, near Aix-la-Chapelle. This installation began in a small way in 1904 and now comprises 15,000 horse-power in gas engines built by the Augsburg & Nürnberg Company, the latest installed being two twin tandem engines of from 2,600 to 2,800 brake-horse-power, and this is said to be the largest plant running with coke-oven gas. A producer plant has been erected at the works as a standby to the coke oven supply of gas; and Professor Lange, when testing the engines, found they were able to work at a full load without any alterations to the valves or governing gear, either with coke-oven gas having a value of 340 to 450 B. T. U. per cubic foot or with producer gas having a value of only 113 B. T. U. per cubic foot, quality governing being used on these engines. On testing the rather smaller sizes of 2,400 horse-power, it was found that, while the consumption was guaranteed to be 8,000 B. T. U. per indicated horse-power, it actually proved to be only 6,862 B. T. U.

Most of the power produced is used locally for operating the mines, but a portion of it is stepped up from 5,500 to 35,000 volts and transmitted to the Eschweiler pit, 11 miles away.

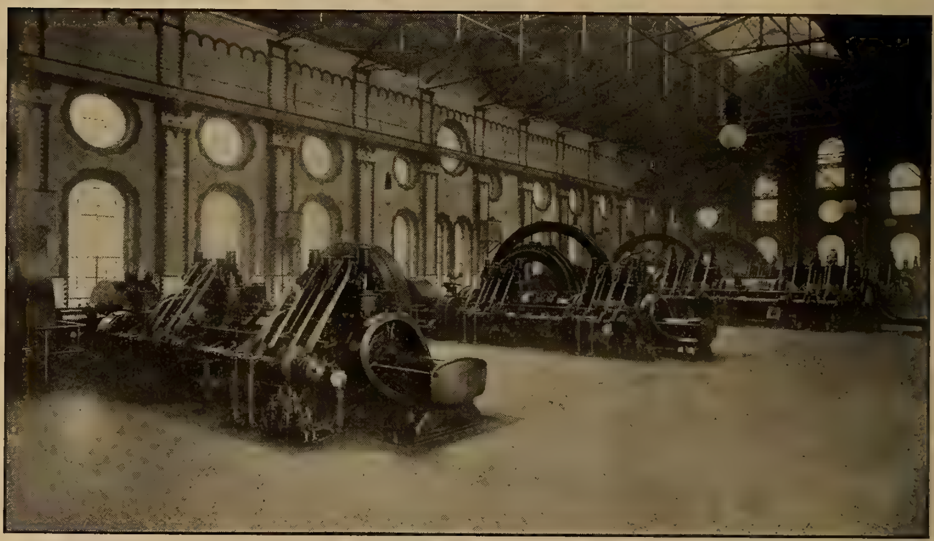


FIG. 9.—NÜRNBERG ENGINES AT THE ESCHWEILER MINES, ALSDORF

FIG. 10.—GAS-BLOWING ENGINE AT THE BARROW HEMATITE STEEL COMPANY, LTD., BARROW-IN-FURNESS, 1,100 HORSEPOWER. THE LILLESHALL COMPANY, OAKENGATES

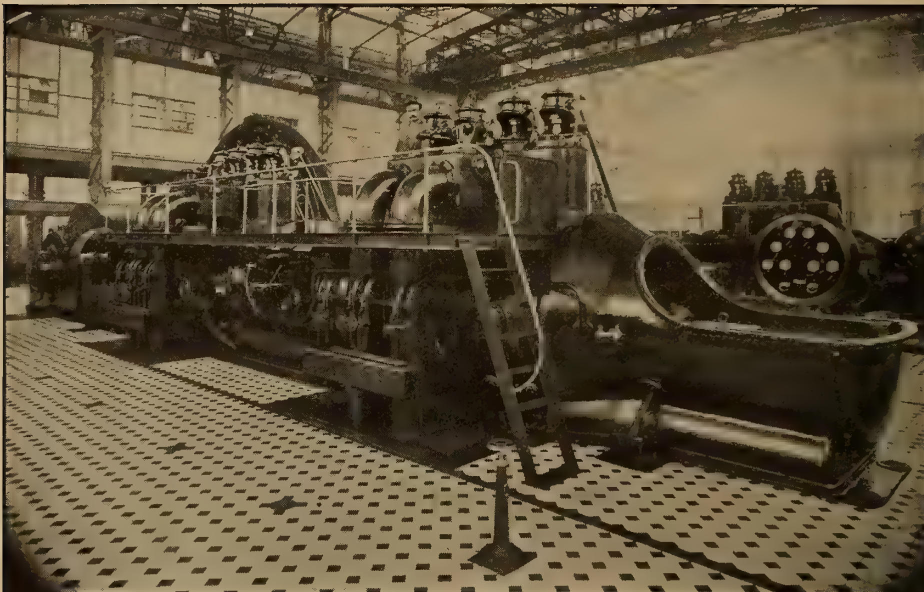


FIG. 11.—2,000-HORSEPOWER THYSSEN ENGINE AT BRUCKHAUSEN

For some time the largest gas engines at work on the Continent were those built by Messrs. Haniel & Lueg for the Schalke works, in Westphalia. These were twin-tandem engines, and would develop nearly 4,000 horsepower; but recently the Mulheim works of Messrs. Thyssen & Co. have constructed and have running continuously a double-acting, four-cycle gas engine with a stroke of 4 feet 7½ inches, and with two cylin-

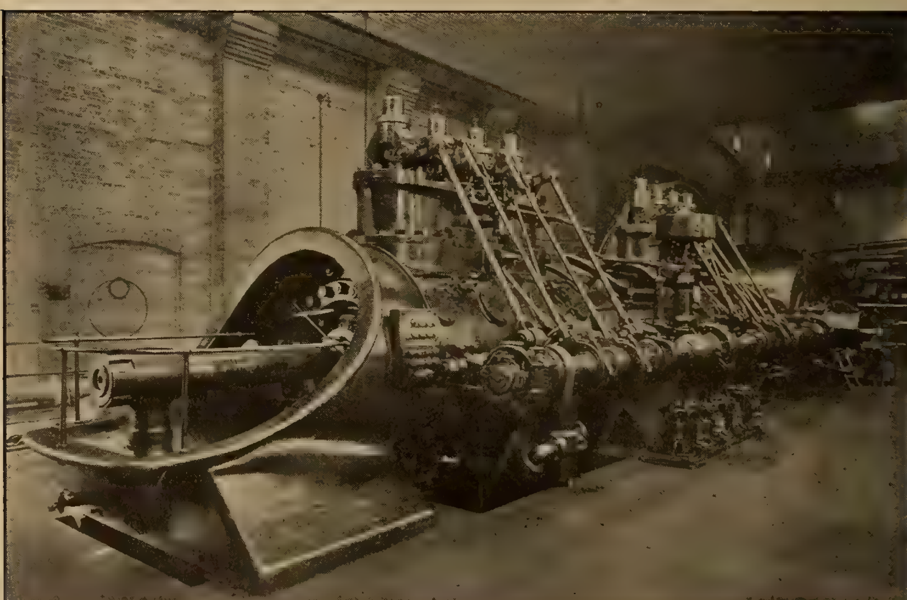


FIG. 12.—TANDEM EHRHARDT & SEHMER ENGINE

ders, arranged tandem, 4 feet in diameter. At 94 revolutions per minute the normal load of this tandem engine amounts to 2,600 horse-power, and if it were built as a twin-tandem engine it would be capable of giving over 5,200 horse-power; so far, this is the largest four-cycle tandem gas engine built on the Continent. The writer regrets not being able to illustrate this particular engine, but Fig. 11 shows another of much the same design built by the same makers, this is as yet one of the largest engines running on Mond producer gas. Messrs. Ehrhardt & Sehmer's engines will doubtless be familiar to many readers, as this firm has always been ready to give opportunities for visiting their installations; indeed, all the Continental makers have done a considerable amount of missionary work on behalf of large gas engines.

The type of engine already referred to as being built by the John Cockerill Company has been largely

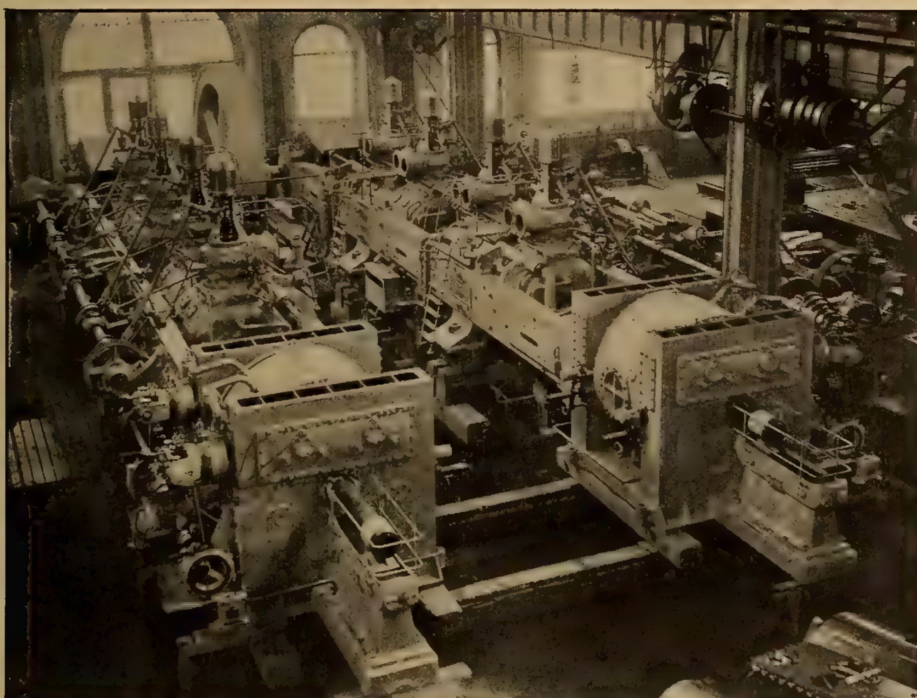


FIG. 13.—TWIN-TANDEM COCKERILL BLOWING ENGINE, BY THE JOHN COCKERILL COMPANY

being of 2,000 horse-power and forming one unit of the magnificent installation at Bruckhausen, where twelve of these engines, aggregating 24,000 horse-power, are grouped together under one roof. Fig. 12 shows an illustration of a 1,200 horse-power Ehrhardt & Sehmer tandem engine which has been for some time running in England driving direct a Mather & Platt dynamo at an important chemical works, and used on the Continent for driving blowing engines, dynamos, and for use in iron and steel works generally. Up to 1,200 horse-power these engines have also been built successfully by Messrs. Richardsons, Westgarth & Co., in England. A large twin-tandem Cockerill blowing engine for the blast furnaces at Ougree Marihaye, near Liège, is illustrated in Fig. 13, which is taken from a photograph of the engine while in

course of erection at the maker's works at Seraing. The four gas cylinders are each 39⅓ inches in diameter by 3 feet 7½ inches stroke, and the blowing cylinders seen in the foreground have the system of air valves introduced by the Southwark Foundry Company and are 5 feet 11 inches in diameter and 3 feet 7½ inches stroke. At a speed of 72 revolutions per minute the engine develops 2,100 horse-power and compresses 28,800 cubic feet of free air per minute to a pressure of 2 atmospheres, and can occasionally for short periods go up to 2½ atmospheres. The illustration shows the continuous side frames with feet opposite the cylinders, which has already been referred to as a peculiarity of the design.

The large four-cycle gas engines which are now being rapidly adopted in America differ in several points from the Continental ones just described, although usually operated upon the same Otto four-stroke cycle and built with the same combination of twin-tandem cylinders in the larger powers.

The principal types of these American engines will be described and illustrated in the next instalment of this article, the British and Continental types having been described in the present one.

THE MANUFACTURE OF HIGH-SPEED STEEL

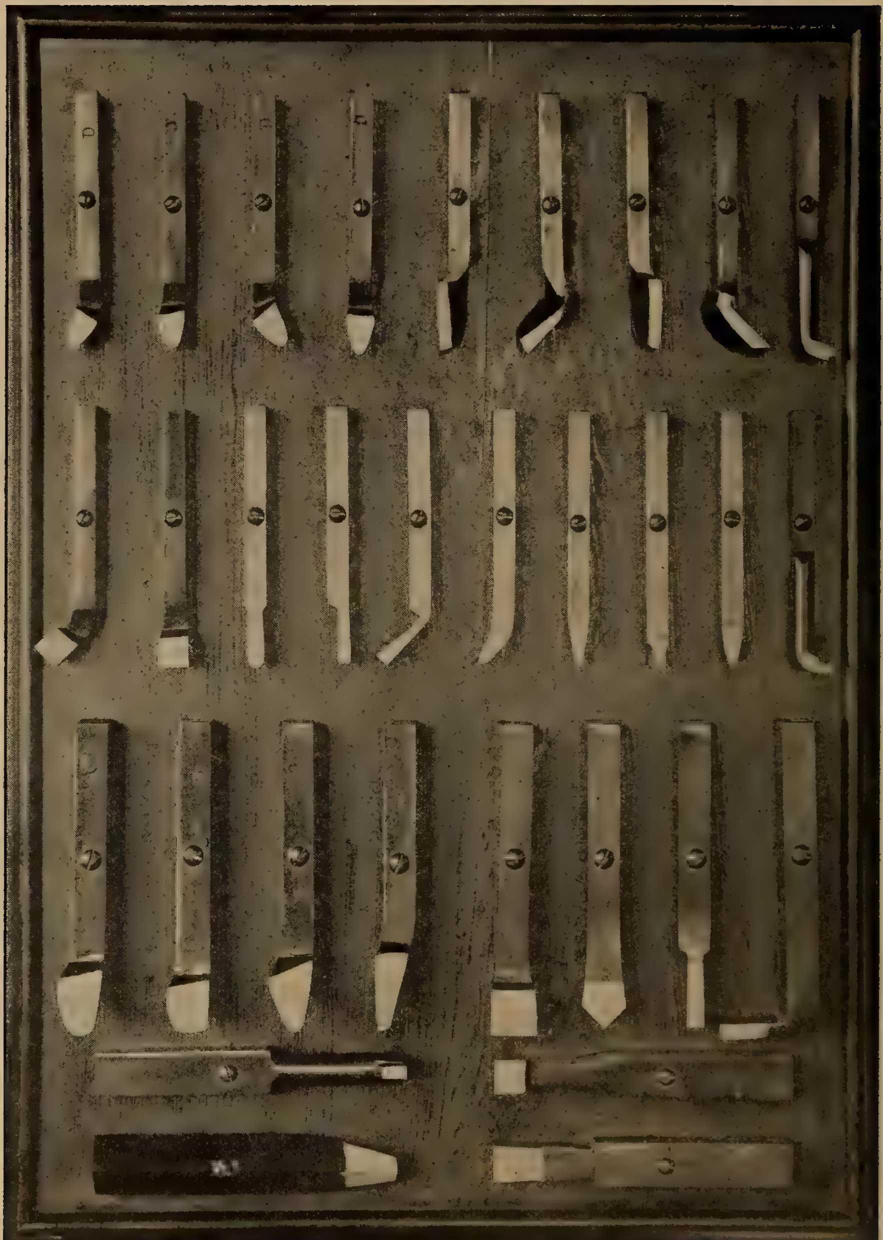
By O. M. Becker

METHODS AND MACHINES FOR GRINDING THE TOOLS

This article, the last of this series, treats of the grinding of high-speed tools. The series started in August last with an article on the manufacture of the steel, the subsequent ones being on the forging of the tools and on the various hardening processes.—THE EDITOR.

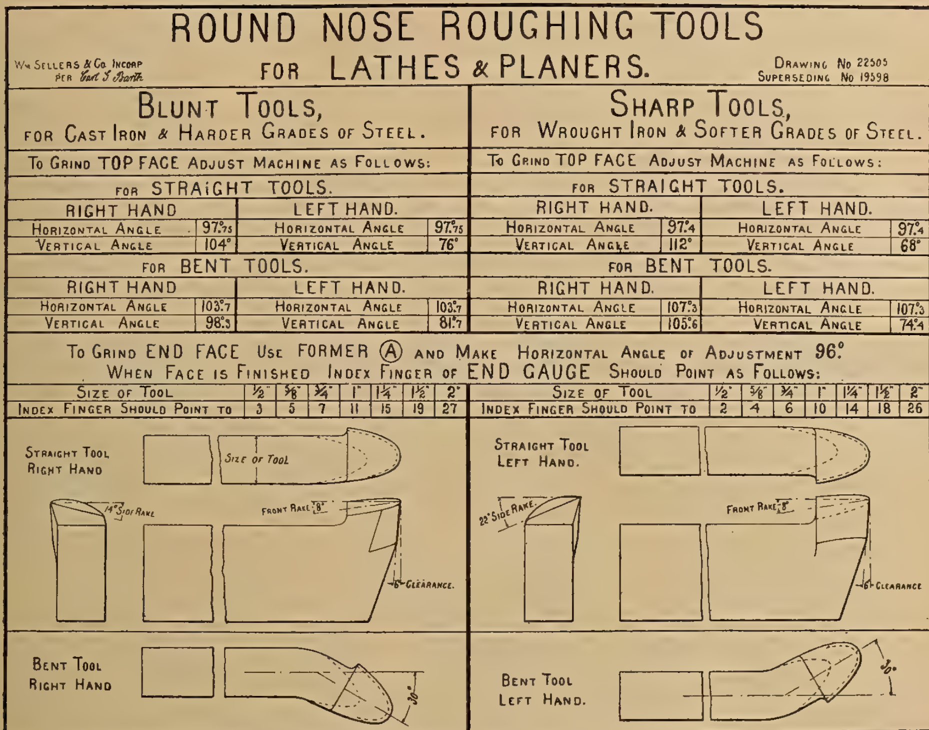
HARDENING has been very generally emphasized as the one most important operation in the manufacture of high-speed steel tools—the steel of suitable quality, of course, being granted. In one sense this doubtless is true, for a well-hardened tool will do moderately good work even when the remaining operations are badly done, or, in the case of some of them, quite omitted. It is equally true, nevertheless, that a tool giving maximum service must have passed through all the operations necessary to its manufacture. These operations, from the bar stock to the finished tool, may be given as forging, or otherwise forming; hardening, tempering and grinding, or otherwise sharpening. Certain of these, of course, are simultaneous in some cases, as when a milling cutter is sharpened before hardening at the same time it is formed. Of these operations, grinding is fully as important as any other, the same care and precision being required for the development of the highest possibilities in a given tool. As elsewhere in the manufacture of high-speed tools,, incompetent or careless workmen or inefficient methods may easily spoil an expensive tool or render it defective, it seems very certain that a large proportion of such tools, as made and used in ordinary practice, are more or less injured by improper grinding. The operation is in many places regarded indifferently, and in consequence there is a serious loss in efficiency. Undoubtedly a good many discouraging trials of the new steel turned out badly more on account of improper grinding than for any other reason. Of course, not every tool plant can be equipped with the most approved machinery and use the very best methods in grinding, any more than in the hardening and tempering of these tools; but it is to be emphasized that the best results can be expected only when efficiency characterizes every detail in the manufacture as well as the use of these tools.

Much has been said as to the kind of stone best suited to the grinding of high-speed steel tools. A good many makers of the steels recommend emery or composition, about as many sandstone, and still others indicate that either may be used under suitable conditions. The fact of the matter seems to be that any of these several kinds of grinders can be used with satisfactory results, if the stone used be selected with reference to the work to be done and the proper conditions maintained. It does not follow that all are equally efficient. The thing to be desired in this respect is that the wheel shall grind as rapidly as possible, leave a sufficiently smooth finish, and yet not overheat the tool. A coarse and hard wheel ordinarily will grind faster than a fine and soft one. For this reason, and also because it can be speeded up much faster, an emery wheel can be made to grind high-speed steel more rapidly than a sandstone. The ease with which emery and composition stones



A SET OF STANDARD TOOLS, FOR COMPARISON IN GRINDING PRACTICE

can be modified in grit and bond to meet the various requirements give them another advantage. While it is probably true that most of the damage suffered during grinding by high-speed tools occurs when emery wheels are used, it by no means follows that these necessarily cause the trouble. The inexperienced or inattentive operator forgets that the emery wheel runs at a speed very much greater than the sandstone possibly can run, and that in consequence the tool pressed against its



ROUND NOSE ROUGHING TOOLS FOR LATHES & PLANERS.

Wm SELLERS & CO. INCORP PER Carl G. Barth

DRAWING No 22505 SUPERSEDING No 19598

BLUNT TOOLS, FOR CAST IRON & HARDER GRADES OF STEEL.				SHARP TOOLS, FOR WROUGHT IRON & SOFTER GRADES OF STEEL.			
TO GRIND TOP FACE ADJUST MACHINE AS FOLLOWS:				TO GRIND TOP FACE ADJUST MACHINE AS FOLLOWS:			
FOR STRAIGHT TOOLS.				FOR STRAIGHT TOOLS.			
RIGHT HAND		LEFT HAND.		RIGHT HAND.		LEFT HAND.	
HORIZONTAL ANGLE	97°.75	HORIZONTAL ANGLE	97°.75	HORIZONTAL ANGLE	97°.4	HORIZONTAL ANGLE	97°.4
VERTICAL ANGLE	104°	VERTICAL ANGLE	76°	VERTICAL ANGLE	112°	VERTICAL ANGLE	68°
FOR BENT TOOLS.				FOR BENT TOOLS.			
RIGHT HAND		LEFT HAND.		RIGHT HAND.		LEFT HAND.	
HORIZONTAL ANGLE	103°.7	HORIZONTAL ANGLE	103°.7	HORIZONTAL ANGLE	107°.3	HORIZONTAL ANGLE	107°.3
VERTICAL ANGLE	98°.3	VERTICAL ANGLE	81°.7	VERTICAL ANGLE	105°.6	VERTICAL ANGLE	74°.4

TO GRIND END FACE USE FORMER (A) AND MAKE HORIZONTAL ANGLE OF ADJUSTMENT 96°.
WHEN FACE IS FINISHED INDEX FINGER OF END GAUGE SHOULD POINT AS FOLLOWS:

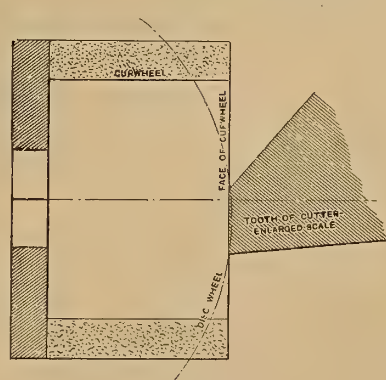
SIZE OF TOOL	½"	⅝"	¾"	1"	1¼"	1½"	2"
INDEX FINGER SHOULD POINT TO	3	5	7	11	15	19	27

SIZE OF TOOL	½"	⅝"	¾"	1"	1¼"	1½"	2"
INDEX FINGER SHOULD POINT TO	2	4	6	10	14	18	26

DIRECTION SHEET USED IN CONNECTION WITH SELLERS' NO. 1 GRINDER

face is heated much more rapidly.

A difficulty frequently met with heretofore in the use of these wheels in grinding high-speed steel has been their tendency to glaze and "load," that is, for the cutting grains at the grinding surface to become worn down smooth and dead even and the pores or interstices in the bonding material to fill up with the abraded particles of metal. These two conditions sometimes occur separately, and at others together. When they do occur grinding ceases in proportion as the surface of the wheel is more or less glazed and loaded. To grind, that is, to "cut," the grit at the surface of the wheel must be sharp, not worn down smooth, and the interstices between the grains filled up. A grinder is a sort of cutting tool. The cutters are the infinite number of sharp grains or grit whose angles are exposed at the surface of the wheel. These act individually very much like the broken corner of a file in scratching a metallic surface, getting behind slight inequalities in the surface being ground or forcing themselves into the metal, and in either case pushing off a thread-like filament whose size depends upon the size of the grit and



EFFECT OF GRINDING WITH DISK AND WITH CUP WHEELS

the pressure applied. Evidently there can be no grinding under the conditions just stated; that is, where the grit is worn down smooth or the interstices of the grinding surface filled up to such an extent that the grit does not protrude.

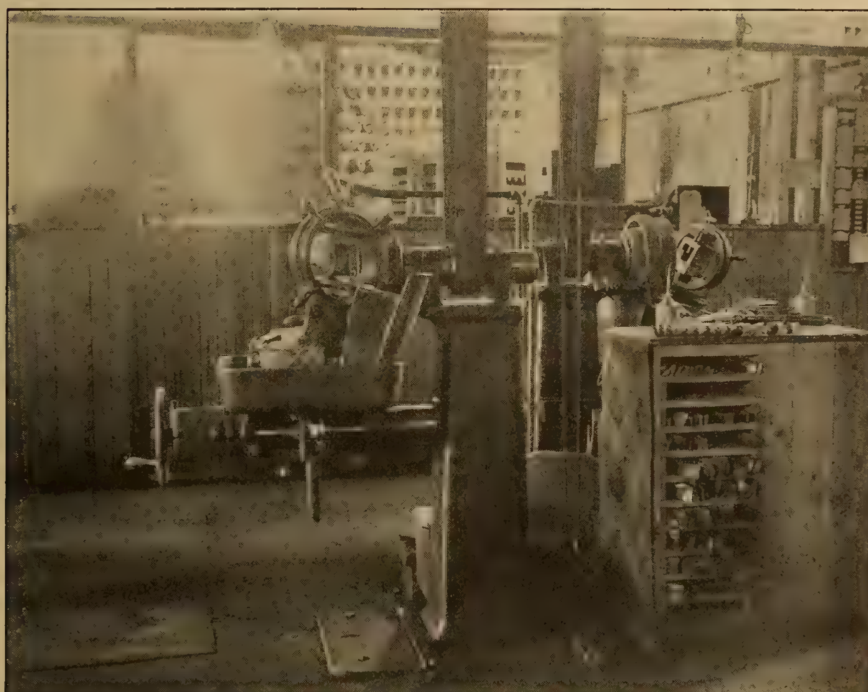
In hand grinding the tendency is, when one or both these conditions prevail, to press the tool the more firmly against the wheel. Since little or no work can be done with the grinding surface in this state, the additional pressure serves only to increase enormously the friction and generally to ruin the tool by the sudden heating of its surface or cutting edge. It may seem singular that a high-speed tool should be spoiled by any temperature to which it might be raised in grinding, for that is, of course, not comparable to the temperatures used in the forging or hardening. The damage comes about in large part through the "drawing" of the "temper," and in part through "checking," or the formation of surface cracks. Softening of high-speed steel begins at a temperature approximating 550 degrees C. (1,100 F.), and is completed near 700 degrees C., or 1,300 degrees F. The lower temperatures in this range are easily possible in careless grinding; and indeed the higher, corresponding to a low red, has been observed at the point of a tool flooded with water. The more frequent injury probably is due to the manner in which the frictional heating occurs—the sudden rise of temperature in the thin outer skin of the tool face applied to the surface of the stone, and consequently its rapid expansion without reference to the unheated portion back of and adjacent to it. The result is that numerous checks or cracks are formed, more or less deep, according to the pressure, speed and duration. If the stone be used wet under these

AN EXPENSIVE METHOD OF GRINDING HIGH-SPEED OR ANY OTHER TOOLS, VIEWED FROM WHATEVER POINT

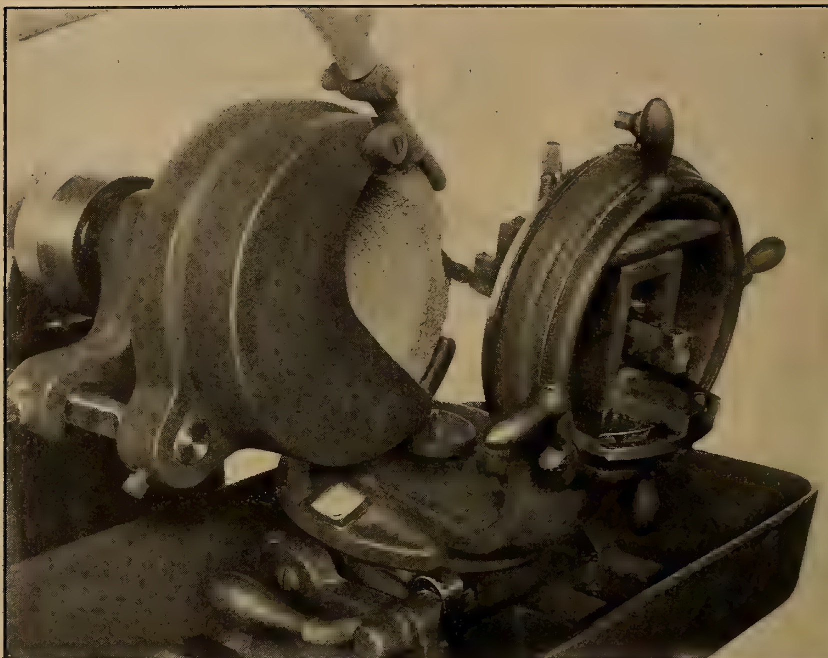
circumstances, the trouble is greatly aggravated; for the cold water, coming into contact with the heated surface, does here just what it does always to high-speed steel—causes a multitude of checks over the whole surface affected.

The whole trouble lies in the use of wheels not suited to the work in hand. It is well enough understood that the use of one form and size of lathe tool, standardized as much as it may be, for all sorts of jobs and on all kinds of material, is not only uneconomical, but exceedingly foolish. Various jobs require particular tools such as are specially adapted to the work in hand. Precisely the same thing holds true of grinding wheels. It is quite as absurd to use the same stone for finishing brass and for sharpening tools, and likewise to use for grinding high-speed tools a wheel made for an entirely different class of work. If a stone be used which has been properly selected, and which is run under suitable conditions, there will be no glazing, even if the pressure be excessive. The latter condition will but tear up the wheel and overheat the tool the faster.

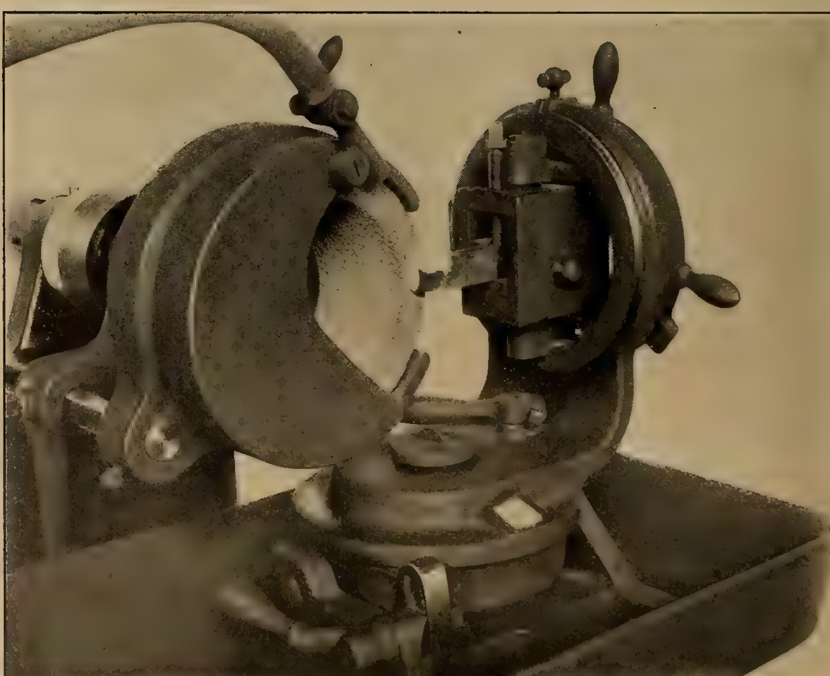
It may be said, in general, that the difficulties just described arise from the use of a wheel too fine in grit or too hard (or close-grained) in bond. Wheels made especially for grinding hard carbon steel tools give but moderately good results when used on high-speed tools. The grain is too fine, and the bond not sufficiently hard or porous. The ordinary run of high-speed tools, such as are used in lathe, planer, shaper, boring-mill, and the like, work, require for moderately rapid and sufficiently smooth grinding a wheel of quite coarse grain. Mr. Taylor recommends for general work a mixture of grits numbers 24 and 30; that is, grit passing through screens with



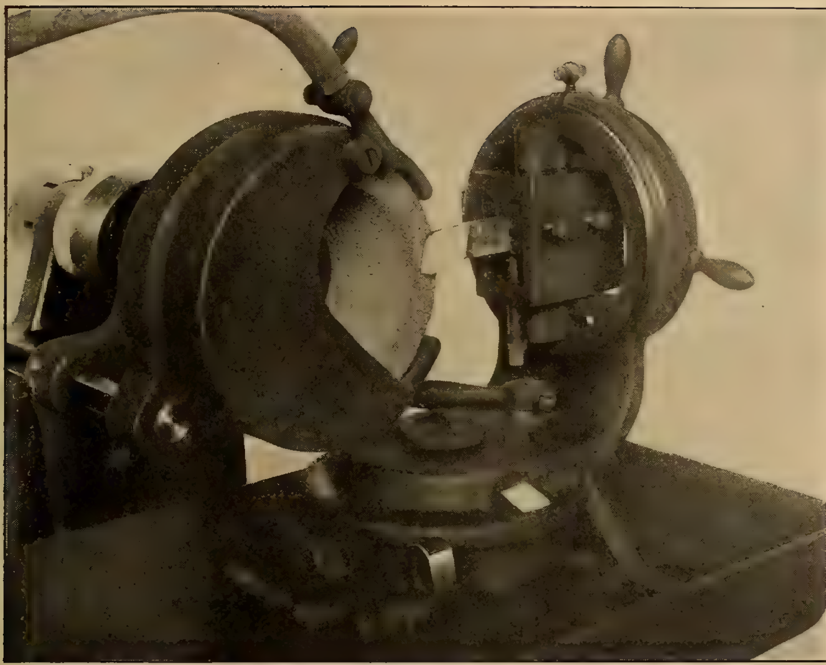
A GISHOLT GRINDER IN CONNECTION WITH THE STOCK ROOM. THIS IS A VERY CONVENIENT LOCATION FOR A GRINDER, THE WORK BEING DONE BY THOSE CONNECTED WITH THE TOOL OR STOCK ROOM



GISHOLT GRINDING MACHINE. GRINDING THE CLEARANCE ANGLE OF A FINISHING TOOL

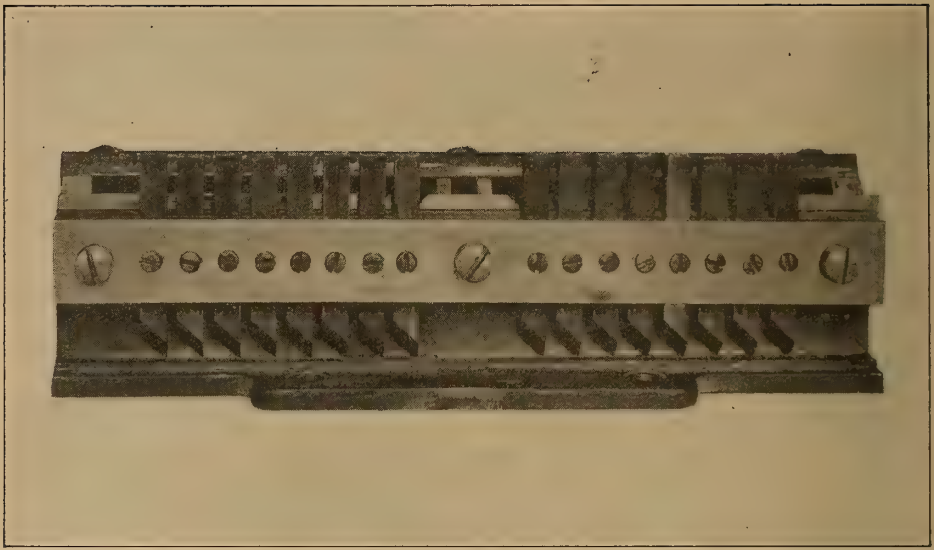


GRINDING THE SIDE OF THE TOOL



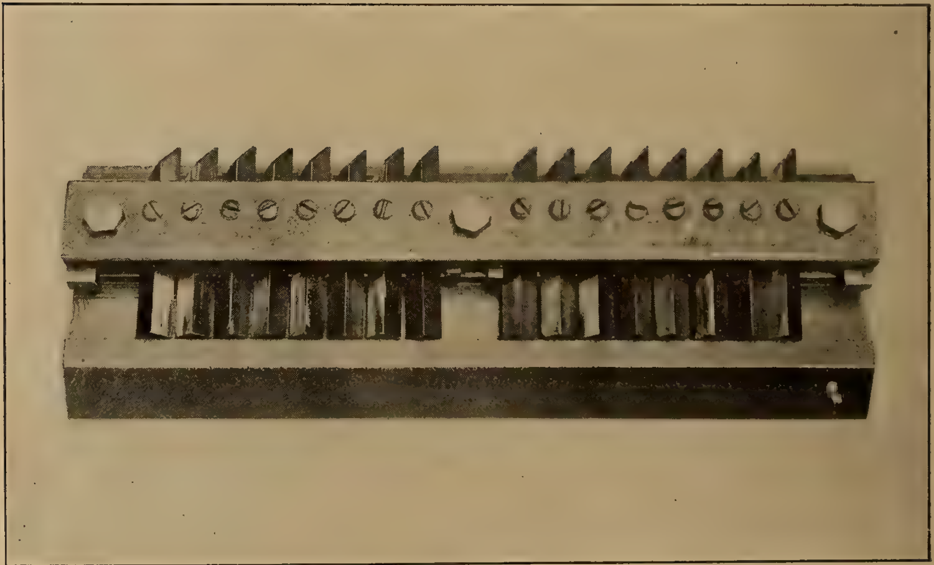
CRINDING THE SIDE OF THE TOOL

GRINDING THE BACK SLOPE OF TOOL

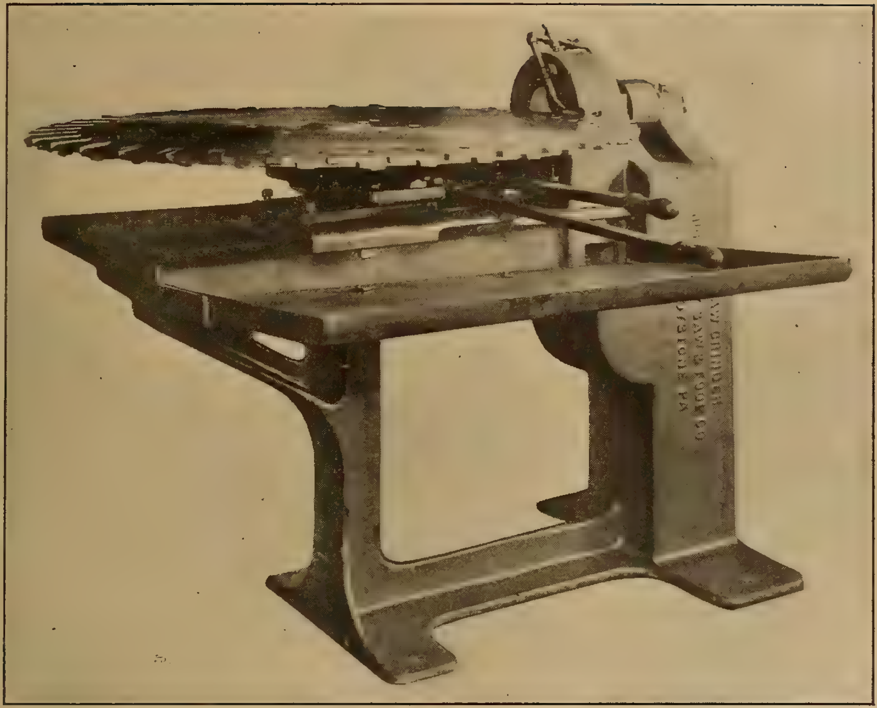


GRINDING JIG DESIGNED BY WM. G. THUMM. ESPECIALLY ADAPTED FOR GRINDING INSERTED CUTTERS FOR A LAGE FACE MILL

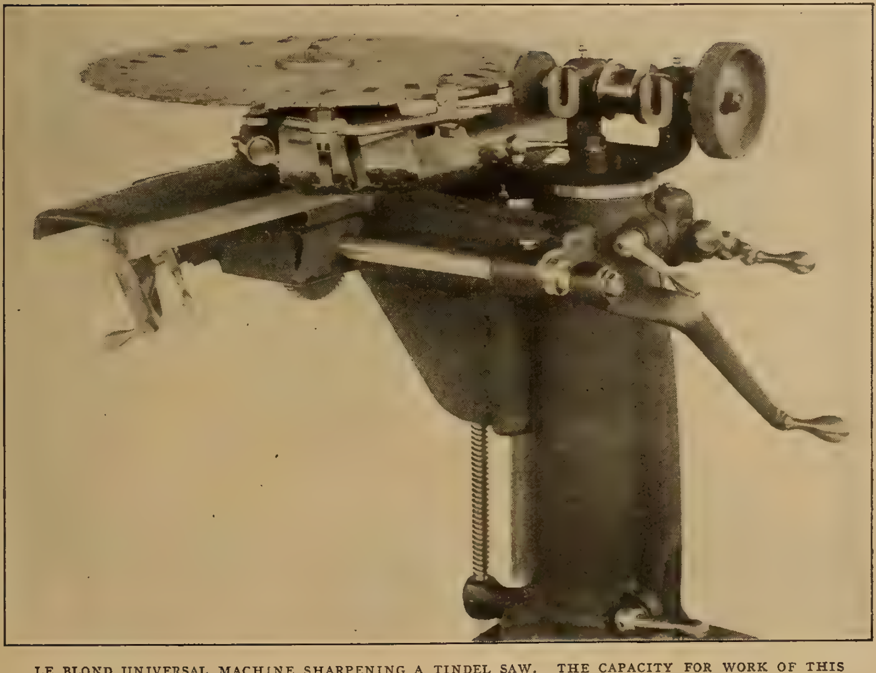
openings respectively 24 and 30 to the inch. For all tools such as described above, unless intended for finishing cuts, a 20 combination is entirely satisfactory, and can well be used for all sorts of rough grinding, and even for a good deal of finish grinding. It is a mistake to suppose that to produce a fine finish in grinding the wheel necessarily must be fine to correspond to the finish desired. This is true of soft metals, but not at all of very hard. The smoothness of the finish in this case, which includes high-speed steel, depends more upon the depth of cut



THUMM'S GRINDING JIG. THIS JIG IS SO DESIGNED THAT FACES AT THE CUTTING END CAN BE UNIFORMLY GROUND, AFTER THE FASHION OF MILLING IN A MILLING MACHINE



A SPECIAL GRINDER FOR THE TINDEL INSERTED TOOTH METAL SAW. TINDEL-MORRIS COMPANY, EDDYSTONE, PA.

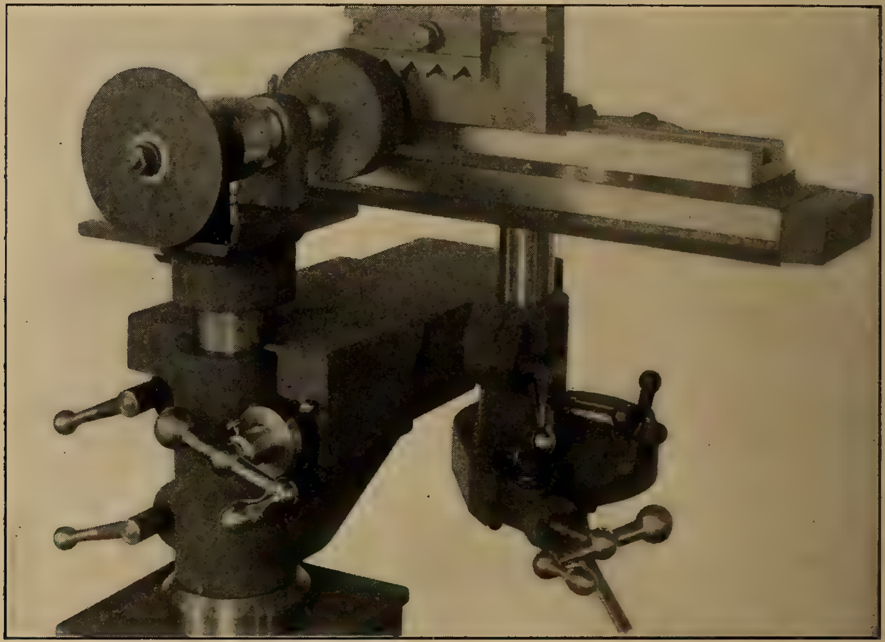


LE BLOND UNIVERSAL MACHINE SHARPENING A TINDEL SAW. THE CAPACITY FOR WORK OF THIS MACHINE IS SURPRISINGLY LARGE

(pressure applied), speed, and softness or openness of the wheel than upon the fineness* of the grain. The grade giving most satisfactory results in connection with the coarse grain already mentioned (20) corresponds closely to that designated in alundum wheels, or a rather "soft" bond. A "harder" wheel will cut faster, but also is liable to glaze and overheat the tool, as already suggested.

Tools requiring very keen cutting edges, like drills, milling cutters, and, in fact, all fine tools, or such as are used for finishing cuts properly speaking, need a finer-grained wheel, as well as a softer one, to insure the best results—say what corresponds to a 60-grain, J grade alundum wheel.

For tools intermediate in finishing quality or size between the class just mentioned and large roughing tools, a wheel of grit and hardness (or softness, rather) between this and that already designated for the roughing tools is often used. A combination 20 and 30 is much in favour. It is a matter of great consequence that the wheel used be just suited to the tools; and for this reason it is very desirable that a sufficient variety, not only in form, but in grade and grain, be kept on hand, so that each batch of tools can be most economically and perfectly ground. The time required for changing wheels is in no wise comparable to that gained and the economy secured as a result of the changes. This raises the question of the organization of the tool-grinding service, which will be considered in another paragraph. To avoid the necessity of truing a wheel each time a change is made, it is desirable that each be mounted on its own arbour and screwed onto the spindle when required, or attached in



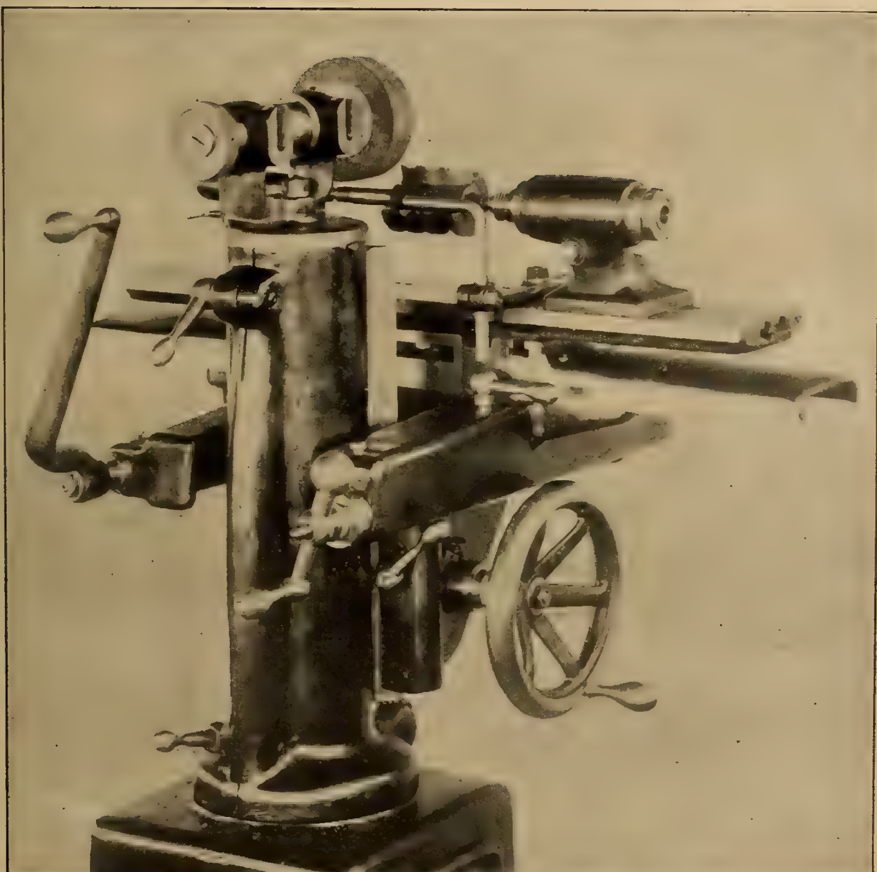
A FORMED CUTTER BEING SHARPENED BY A CINCINNATI MILLING MACHINE COMPANY GRINDER

* It may be mentioned here that the fineness of grain or grit is designated with approximate uniformity by makers of these wheels, by use of the numbers corresponding to the number of holes per inch in the screen used. For indicating "grade," however, each maker seems to be a law unto himself and to use a different nomenclature—most frequently the letters of the alphabet. Even the very general terms "hard," "medium hard," "medium," "soft," and the like, vary more or less as applied by different makers.

some other way to secure perfect centering.

The speed of the wheel should be that recommended by the maker—not "somewhere near" it, but as closely approximating it as possible. This is very important, and the very general disregard of it, the inattention to the maintenance of a suitable running speed—in general as rapid as the bond of the wheel will safely permit—is responsible for much of the trouble that arises in grinding. It may be said with assurance that practically all grinding troubles arise from ignorance of proper conditions, or inattention to them.

There are other conditions also involved in the proper grinding of high-speed tools—and of all classes of work likewise, for the matter of that. Evidently, for one thing, the wheel must be true; and, for another, it must run steadily. To secure the latter condition the machine, whether intended for hand or automatic grinding, needs to be strongly built, even massive, and the spindles and bearings as large as may be consistent with the size of the wheels used. It is a great mistake to suppose that any old, wornout stand will do, even for rough hand grinding. The wheel once properly mounted (between soft metal-faced flanges with a diameter at least a third that of the wheel, or at least with suitable washers between wheel and

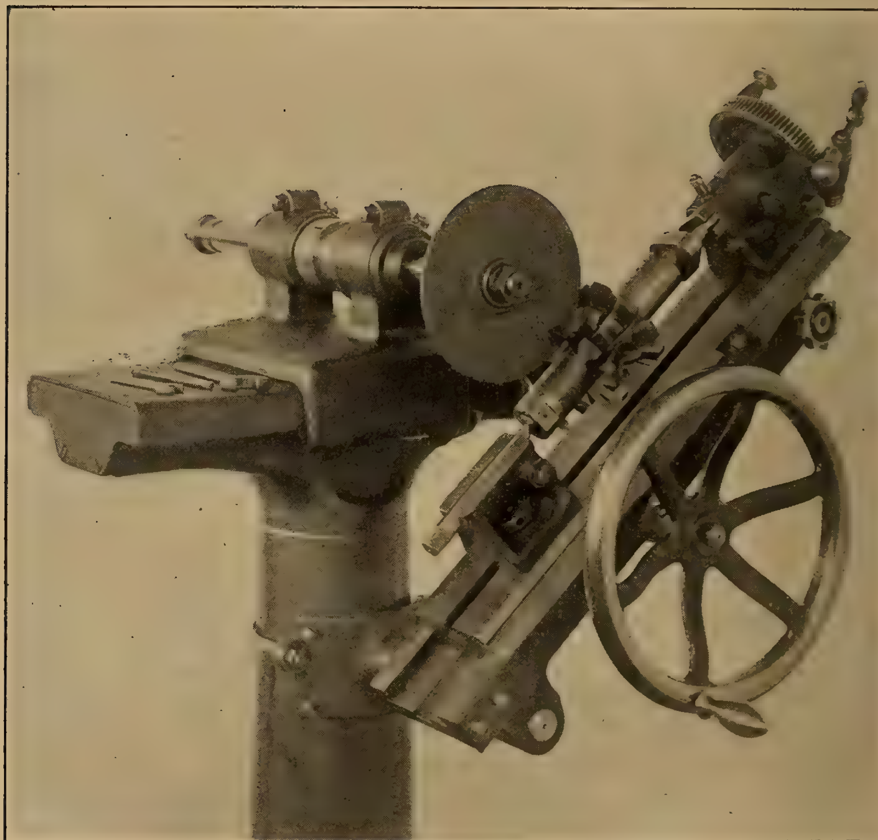


LE BLOND UNIVERSAL MACHINE SHARPENING A FORMED CUTTER

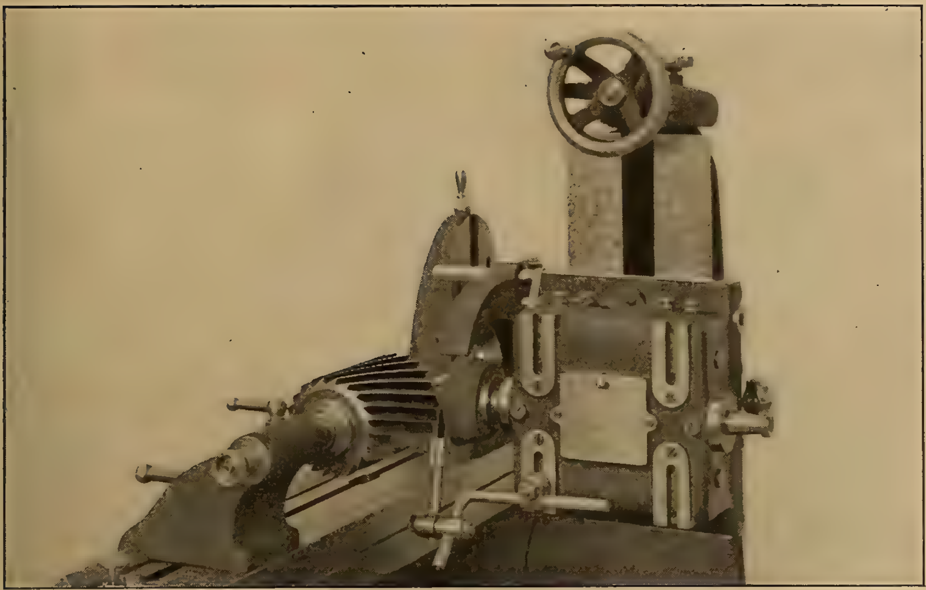
flanges) in a rigid stand or machine, it must be kept exactly true with a diamond dresser held firmly in position by the tool post or other holding device. Dressing by hand is very unsatisfactory, and dressers other than the diamond do not give the very best conditions.

In truing, the diamond must be constantly and thoroughly flooded with water, or it is liable to be flattened. But little of the wheel material should be removed—only enough so that the sound is absolutely even as the dresser passes back and forth over the face of the wheel. Very light pressure, therefore, is required.

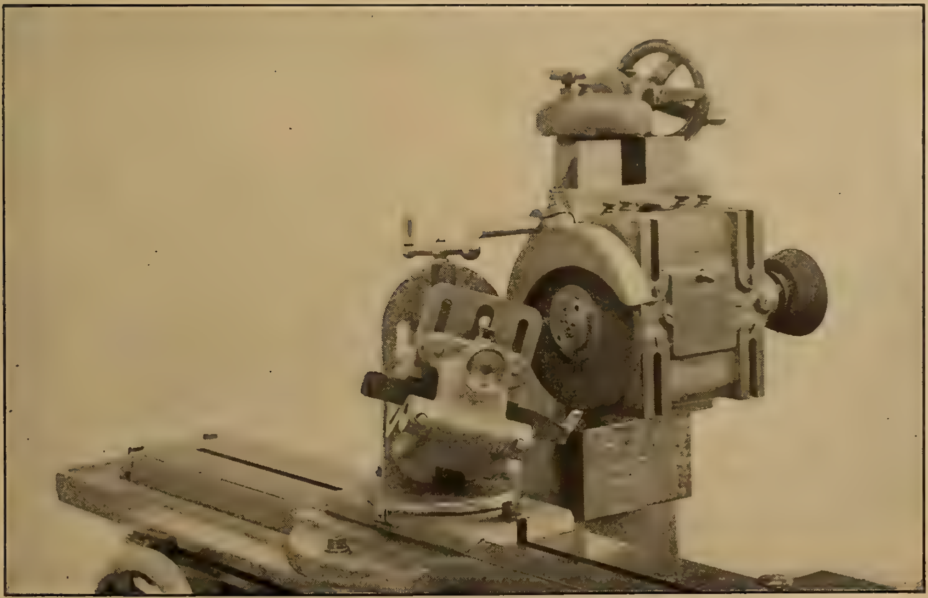
Such precision as is here indicated of course implies automatic or semi-automatic machine grinding of tools, and is not essential in rough grinding by hand, though some of the recommendations obviously apply in this case also. Hand grinding very evidently has no place in a well-regulated shop manufacturing or using tools in such quantity as to warrant an adequate equipment for putting and keeping them in proper shape. Nothing is more certain than that a large part of the ineffective work of tools, and the large loss by breakage common in the past in so many shops, have been due to improper grinding. A drill with lips ground at a guess, one lip sure to be different from the other, as is unavoidably the case when it is ground by hand, even by an experienced workman, clearly goes into its work



BROWN & SHARPE GRINDER AT WORK ON A FORMED CUTTER



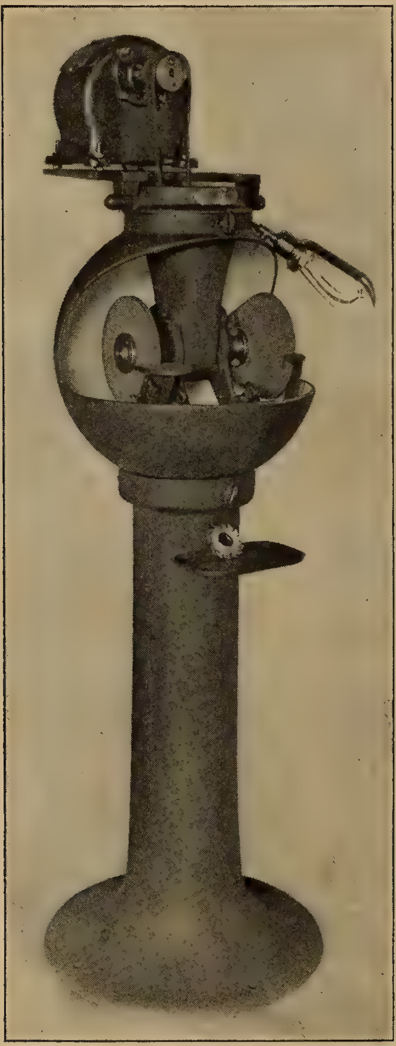
THE DIFFICULTIES FORMERLY ATTENDING THE ACCURATE GRINDING OF SPIRAL MILLING CUTTERS HAVE BEEN PRETTY WELL ELIMINATED IN SEVERAL RECENT UNIVERSAL CUTTER GRINDERS. THIS CUT ILLUSTRATES A BROWN & SHARPE MACHINE GRINDING THE LAND BACK OF THE CUTTING EDGE



IN SHOPS USING RELATIVELY FEW TOOLS, A GRINDER RESEMBLING THIS BROWN & SHARPE MACHINE IS VERY DESIRABLE, SINCE IT IS AVAILABLE FOR PRACTICALLY ALL CLASSES OF TOOLS; INCLUDING THOSE OF THE LATHE AND PLANER CLASS

with strong chances of being broken and likewise of turning out imperfect holes.

Drilling cutters, lathe tools, and the like, of course, are, from their forms,

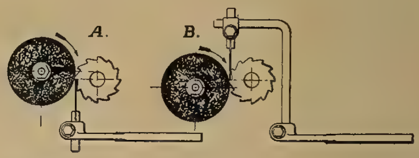


SELF-CONTAINED FLOOR GRINDER. O. S. WALKER & CO., WORCESTER

This grinder has much to commend itself where hand grinding is permissible. The rotating hood forms also a bowl which may be kept filled with water, for the collection of dust. Caliper rests, as here shown, are essential in the hand grinding of high-speed tools.

less liable to breakage under strain; but inequalities in cutting edges, especially so in the teeth of milling cutters, core reamers, and the like—inequalities inevitable in hand grinding—very evidently show up in the surfaces they leave behind. It should, therefore, be perfectly obvious that hand grinding has no place in any well regulated shop manufacturing or using enough tools to require adequate equipment, except possibly in roughing tools to approximate size, and that the precision above recommended is none too great to insure the highest efficiency in high-speed tools.

As to the number and kinds of machines installed, this naturally will depend very largely upon the kind and quantities of tools used. In a shop of any size it is likely that at least one drill grinder is required, one

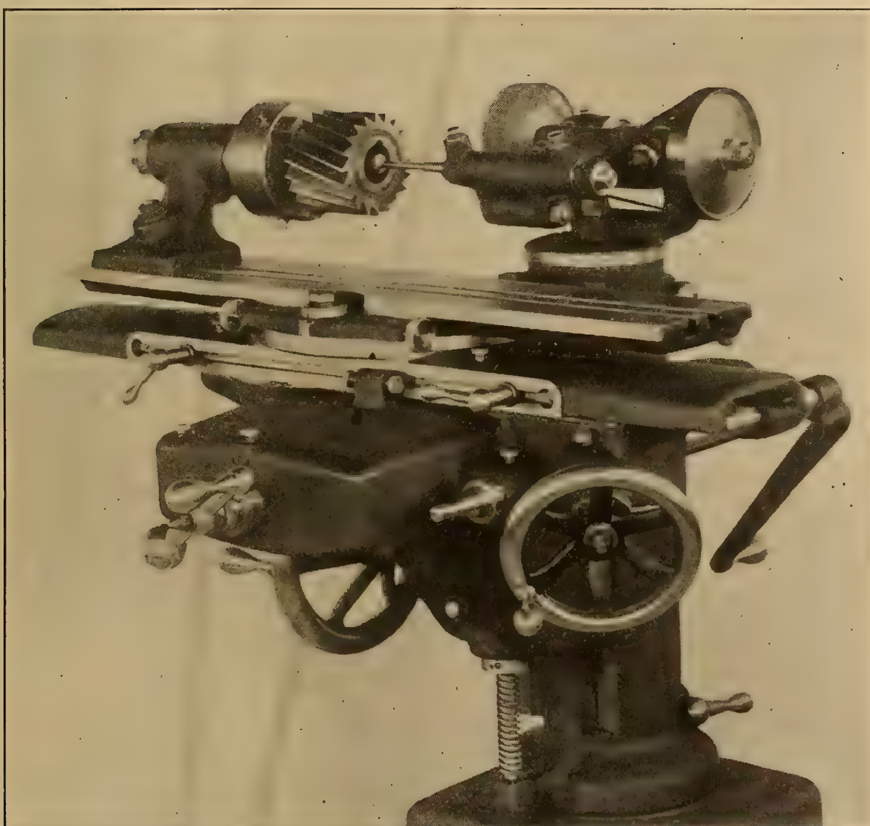


High-speed tools are best ground by revolving the wheel against the cutting edges, as shown in *B* above, rather than with the teeth, as in *A*. The former method prevents burring and allows faster grinding. The cutter must be held firmly against the rest, either by hand or otherwise.

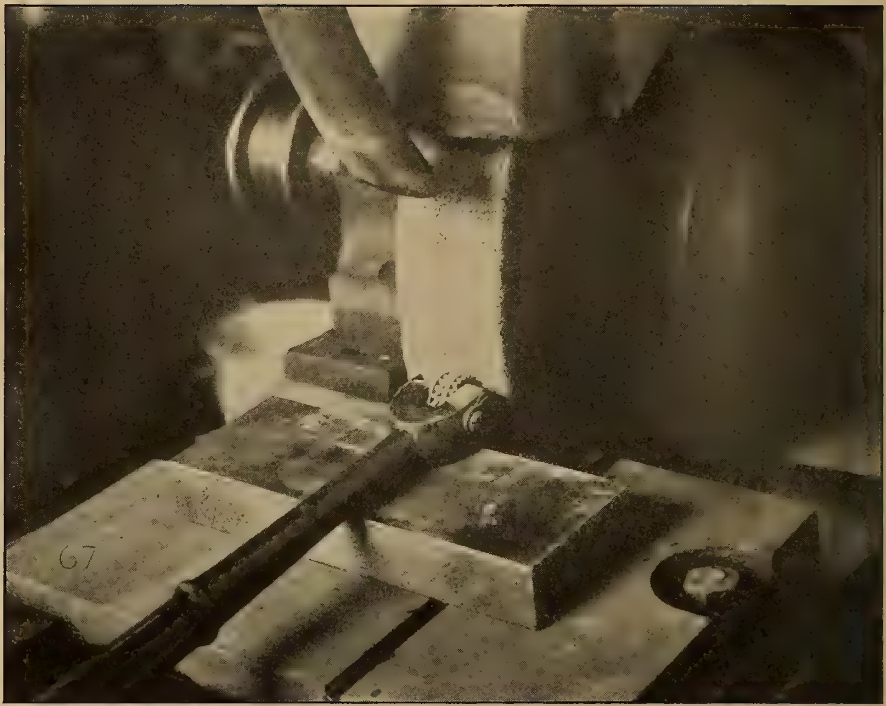
easily adapted to the grinding of all sizes used. Most of the drill grinders now offered conform to the two prime essentials—freedom from vibration and adjustment for maintaining uniform lip angles and curves at the points for all sizes of drills used. Since lathe and like shaped tools form by far the greater portion of all the tools in most shops, a universal machine adapted to the grinding of these tools is essential also. Milling cutters can be successfully ground only in a machine designed for that purpose, or in a universal grinder provided with fittings and adjustments such as to adapt it to this work. Cup wheels, used in common with disc grinders or other forms of tools, are required for most work of this sort, since this shape of wheel

allows the proper facing and backing off of spiral and other difficult shapes of cutters. The cup wheel gives a straight clearance or land instead of a curved, such as is obtained (except unusual precautions be taken) when tools are ground on the periphery of a disc wheel. This method of grinding by the use of cup wheels, therefore, does not undercut the edge; but, on the other hand, leaves it in the best possible form and condition for effective work and maximum life of a grinding.

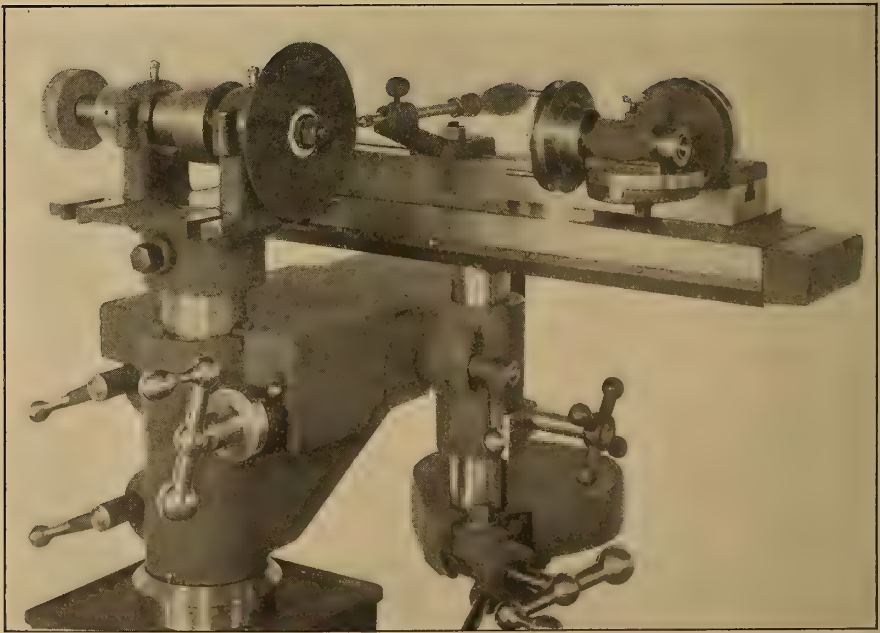
Some grinding machines are provided with positive feed devices for forcing the tool against the wheel. There is no objection to this arrangement if the feed is light, as already recommended, and provision is made at the same time for moving the tool or wheel in such a way that one passes across the face of the other to a greater or less extent during the whole time of the grinding. If tool and wheel face maintain the same relative position, even with a light feed, the chances are that they will quickly come to fit against each other very closely, the cutting face of the wheel gets smooth, grinding proceeds slowly or entirely ceases, and the tool rapidly heats up, just as if the wheel were glazed—which it sometimes is under these circumstances. Such a condition is most likely to occur when the face of the tool is rather large, and in this case especial care is to be observed when grinding with a flat surface. Grinding across the face with



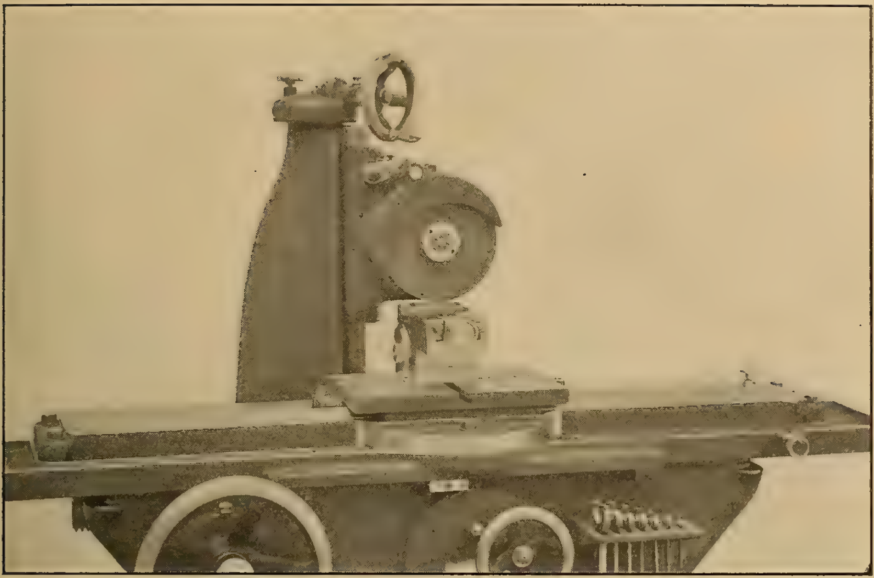
INTERNAL GRINDING IS USUALLY DONE BY THE USE OF AN ATTACHMENT FOR THE PURPOSE, AS IN THE CASE OF THE LE BLOND GRINDER HERE ILLUSTRATED



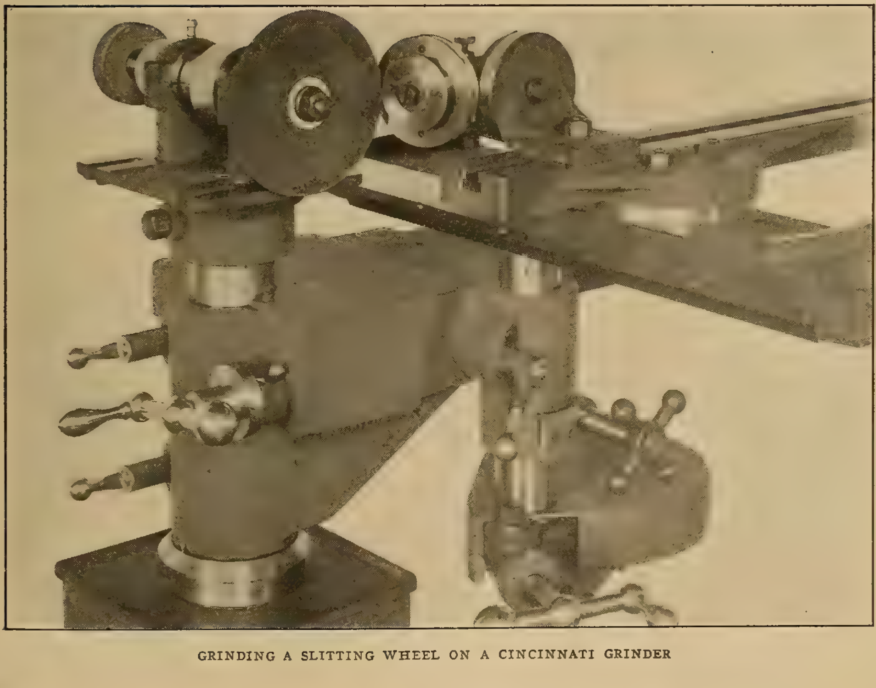
DRESSING AN EMERY WHEEL. THIS METHOD IS GOOD ENOUGH FOR MANY KINDS OF WORK, BUT NOT FOR ACCURATELY GRINDING HIGH-SPEED TOOLS



THE DRESSER SHOULD BE A DIAMOND TOOL, HELD FIRMLY IN A POST, AS SHOWN ON THIS CINCINNATI NO. 2 GRINDER



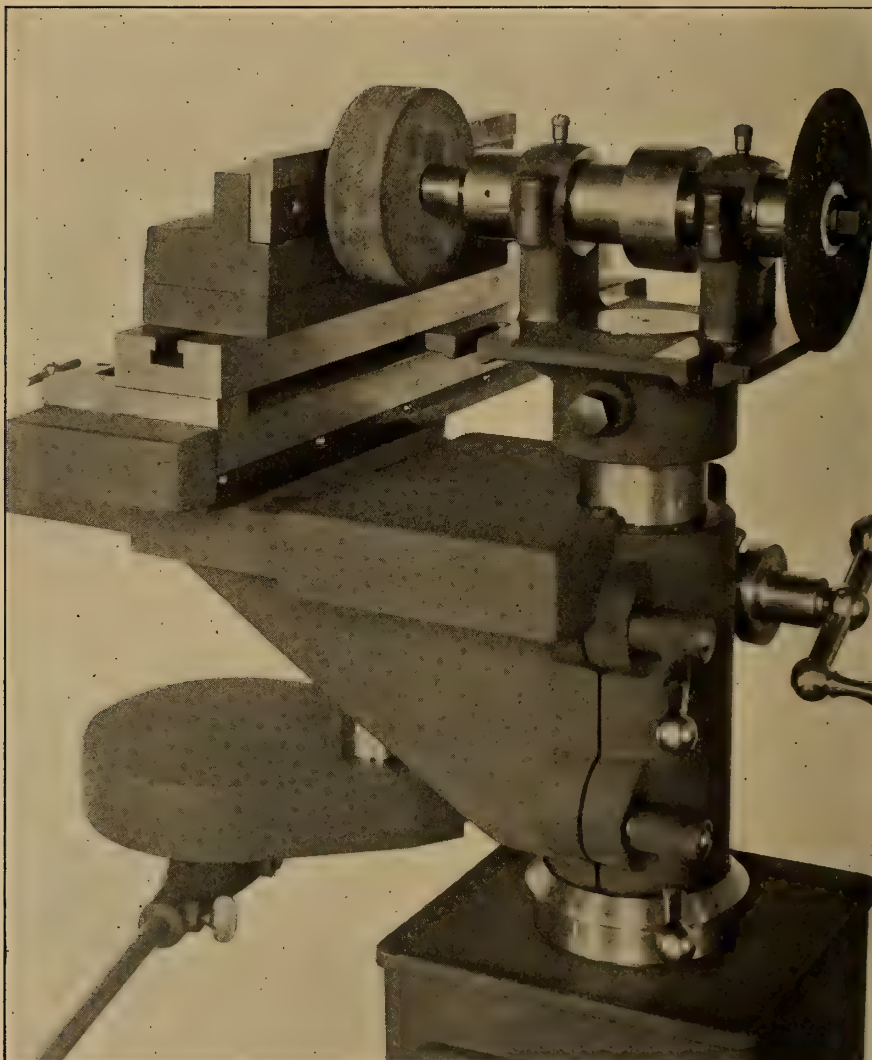
FACING A DIE WITH A BROWN & SHARPE UNIVERSAL GRINDER



GRINDING A SLITTING WHEEL ON A CINCINNATI GRINDER

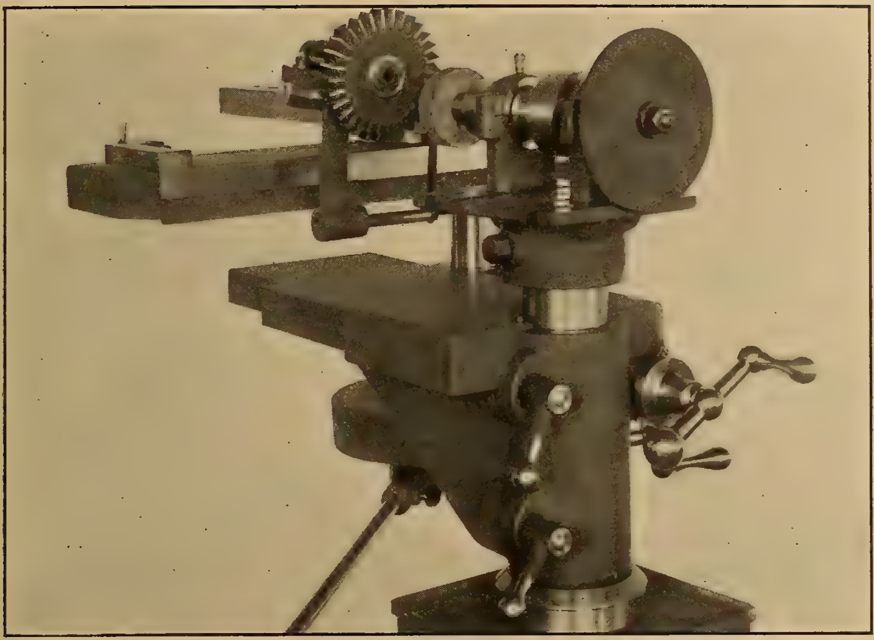
the angle of a wheel having a V-shaped instead of a band periphery eliminates this trouble, though, perhaps, it sometimes reduces the rapidity of the work and at the same time leaves a more or less curved face, according presses against a wheel surface, very little, if any, lubricant gets between, so that the purpose of flushing is in large measure defeated.

As to the respective merits of wet and dry grinding, it does not seem



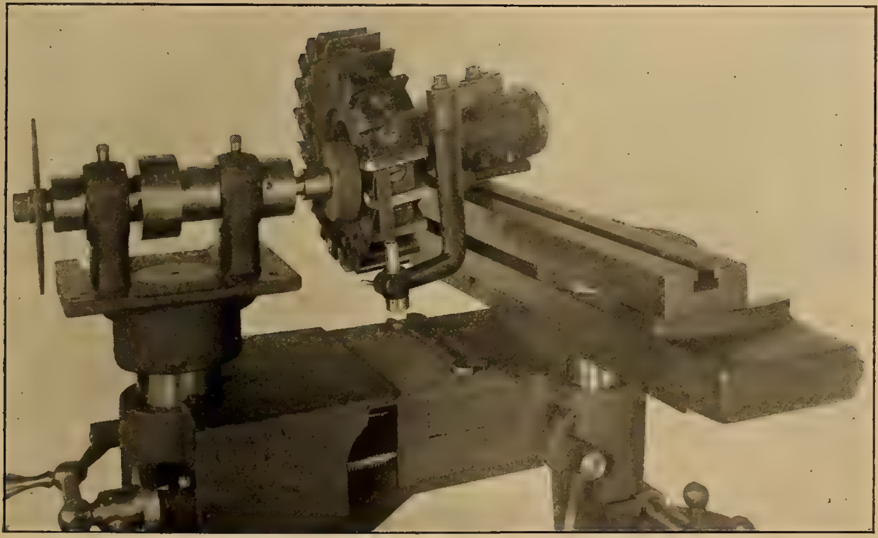
A NO. 2 CINCINNATI MACHINE FACING A SHEAR-BLADE

to the diameter of the wheel, as is the case always in grinding on the periphery of a wheel. The method makes it possible to flush thoroughly, a difficult thing to do in flat grinding. When a relatively large surface safe to hazard a square statement. Many have found, or think they have found, wet grinding advantageous; and many others seem to have a contrary experience. The purpose of wet grinding, of course, is to cool the



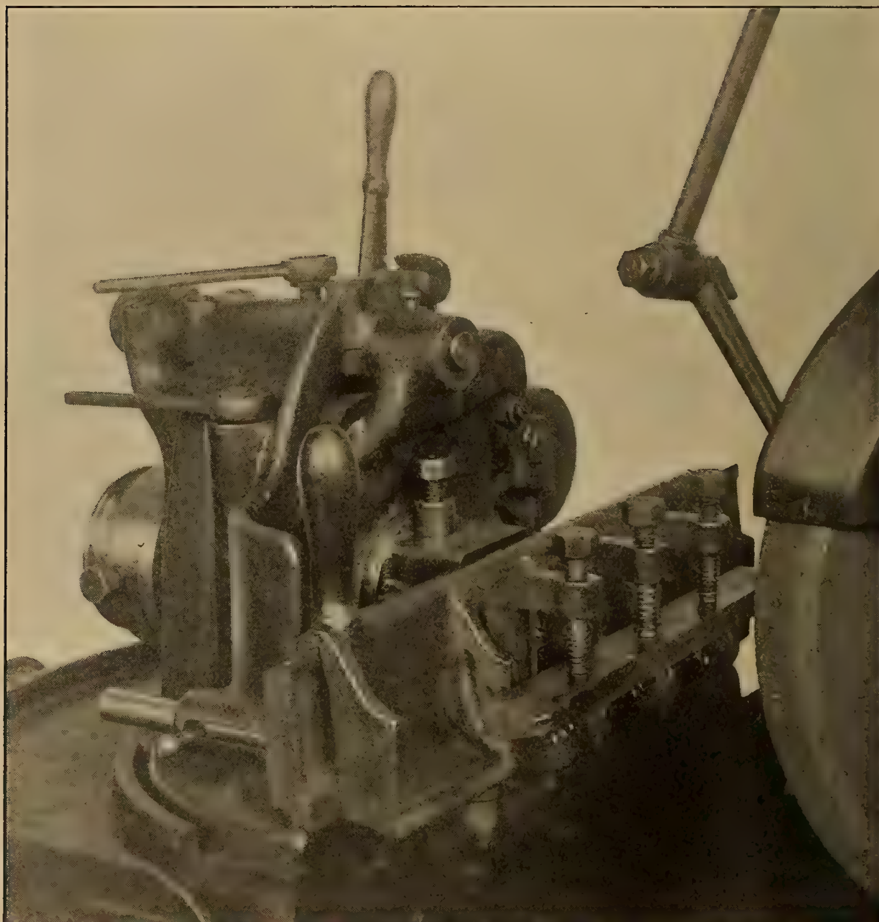
SHARPENING A PLAIN MILLING CUTTER ON A CINCINNATI GRINDER

tool, and therefore to allow more rapid work, and incidentally to eliminate dust. With suitably hooded machines the latter is effectually removed; and it is a question if the damage often done tools in wet grinding does not much more than offset the possible increased speed. If the amount of water (soda or soapy water, with possibly the addition of a small proportion of oil, alone should be used) thrown against the tool is very large and the stream is closely confined to the place where the work



AN INSERTED TOOTH MILLING CUTTER BEING SHARPENED BY A CINCINNATI GRINDER

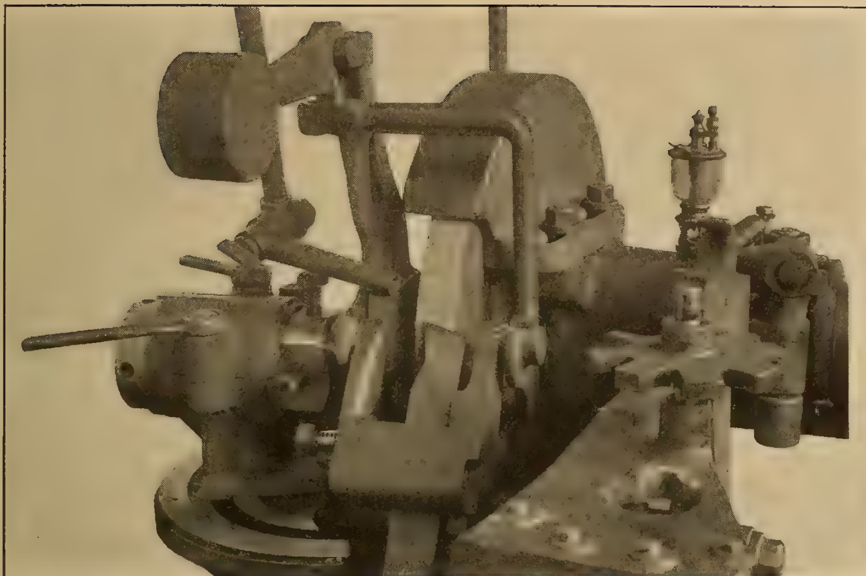
is done, considerable is gained in large work. There is, however, the practical difficulty of forcing water between wheel and tool surfaces where it can keep the face cool, all the greater because the amount should be large but the speed of delivery slow; and it is doubtful under these circumstances if the liability to more or less rounding rather than flat. On such work as milling cutters, reamers, drills, and the like, dry grinding seems preferable; and, indeed, few machines are designed for their wet grinding. The sandstone, if used, of course, must run wet; and this is a good reason why it is best to leave it alone for most, if not



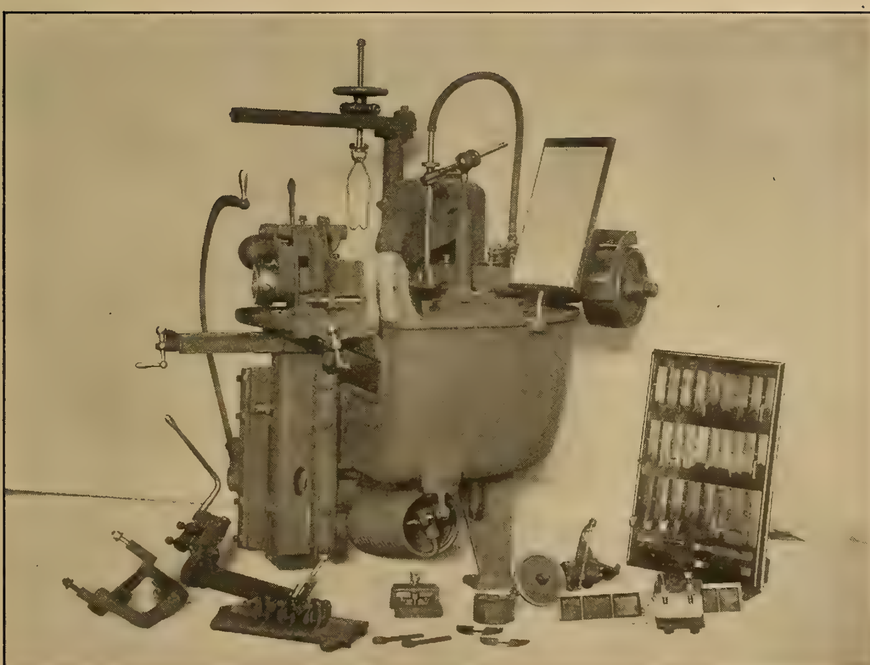
TRUING UP THE BOTTOM OF A LATHE TOOL IN A SELLERS GRINDER. A SUPPLEMENTAL CHUCK IS USED FOR THIS PURPOSE

checking by reason of the contact of the water with the (at times, at any rate) over-heated surface does not do more damage than good. However that may be, wet grinding is very largely practiced in connection with large and simple tools, especially where the surfaces to be ground are for all, grinding of high-speed tools.

Modern emery or composition stones are not affected by oil, when well soaked, and do not, so far as reported, have their cutting qualities impaired. It would, therefore, seem that if oil were used as a lubricant in grinding all classes of high-speed

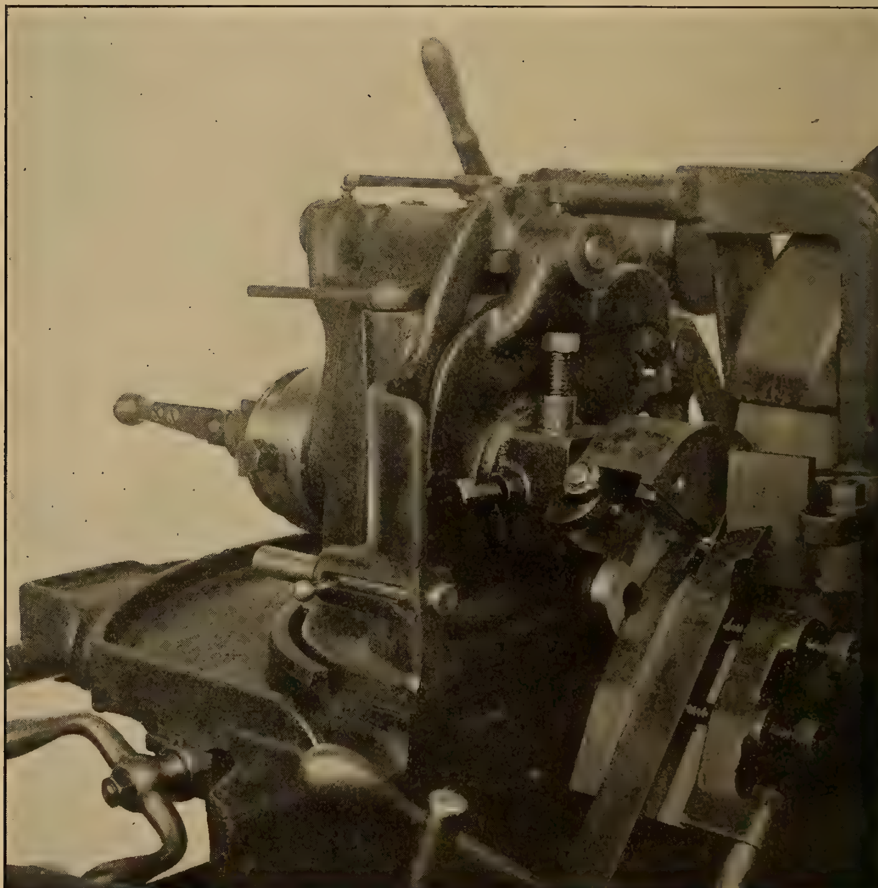


GRINDING A STRAIGHT ROUGHING TOOL ON A SELLERS GRINDER



A GRINDER FOR FLAT-FACE TOOLS, MADE BY WILLIAM SELLERS & CO., INC. NOTE THE WHEEL WITH A V-SHAPED PERIPHERY

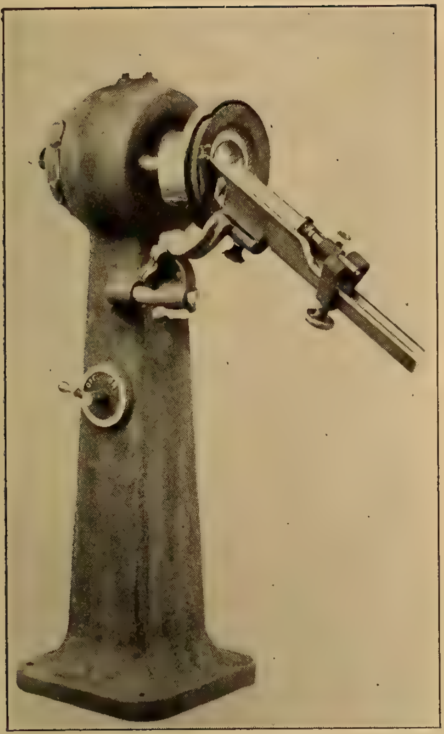
steel tools all the advantages of wet grinding would be obtained with none of its disadvantages. The very considerable waste from "spattering" could no doubt be eliminated by suitably constructed nozzles and hoods. All grinders should be hooded, anyway; and as for nozzles, until recently nobody seems to have thought



GRINDING A FORMER PLATE BY WHICH TOOLS MAY BE SUBSEQUENTLY EXACTLY REPRODUCED. WM. SELLERS' MACHINE

it worth while to use anything other than a piece of pipe. Recently a non-spattering nozzle has been introduced. With some attention to these points oil grinding would seem to promise much in this new field.

Whatever may be the several opinions respecting sandstone and emery wheels and dry or wet grinding of hardened tools, which is the kind so far under consideration, it seems to be pretty generally agreed that for pre-grinding—that is, for grinding before hardening—a dry emery wheel is most satisfactory. With a soft or open and coarse wheel material can be removed with great rapidity and without danger of harm to the tool. Sometimes the tool is ground while still hot from the forging heat; and, indeed, this is recommended where convenient. It is no disadvantage even though the tool be still red-hot. The advantage of thus pre-grinding manifestly is in this, that the tool is still soft, and the reduction is much more rapid than after



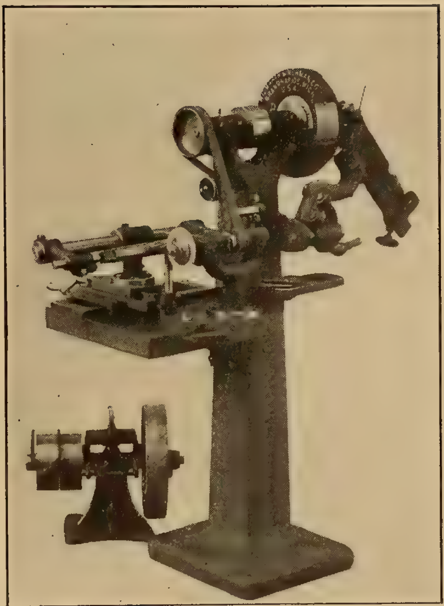
YANKEE DRILL GRINDER. MOTOR-DRIVEN AND ENTIRELY SELF-CONTAINED

This machine, like others of the Wilmarth & Mormon make, has a holder so swung as to grind with a correct clearance.

the tool has already been hardened.

The finish grinding obviously need be relatively slight. This refers to the surface of the tool in general; for at the cutting edge the finish grinding, when rough grinding precedes the hardening, must be severe, if the full efficiency of heavy tools is to be developed. It is a matter of remark among the users of high-speed tools that, in general, they do not work up to their highest possibilities until after two or more grindings. The reason is simple. The high hardening temperatures to which they are subjected affects the sustaining power, especially at the cutting edge, where the danger of "burning" the steel is greatest. Evidently a tool will dull or break down much more rapidly when any portion of the injured skin remains than when this has been removed; and quite evidently, also, the tool must either be ground several times in the customary manner, or the burnt portion must be removed by a severe single grinding, in order to bring out its full possibilities at the first use. On lathe, planer and similar tools 1-16 inch is ordinarily none too much to grind off the cutting edge the first time, and on large tools rather roughly forged more is desirable. On fine cutters with keen edges, hardened at a somewhat lower temperature, no such heavy first grinding is necessary. Ordinarily such tools are set at work without grinding subsequent to hardening.

Carbon steel tools are ground with the wheel running toward or from the cutting edge, at the fancy of the grinder usually, and good edges can be secured either way—provided, in the second case, the burr be removed by honing. High-speed tools are preferably ground with the wheel running against the cutting edge,



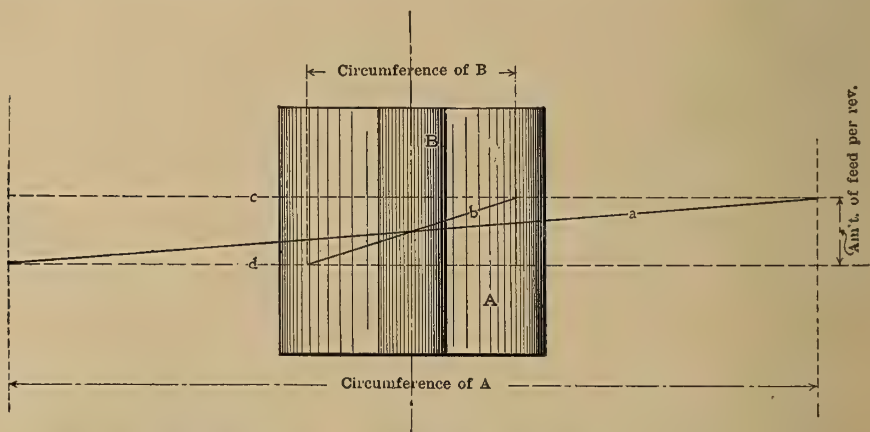
WILMARTH & MORMON COMPANY YANKEE DRILL GRINDER, WITH ATTACHMENT FOR UNIVERSAL GRINDING

Very desirable in a small shop with a considerable range of tool grinding work.

most grinders being in this way able to get the better results. It is not desirable that the grinding face be run along a cutting edge, though in certain cases this may be unavoidable. Revolving cutters, when so ground—that is, with the wheel rotating against the cutting edge—need to be rigidly held against the tooth rest; otherwise there is likelihood that they may be drawn out of proper position by the wheel and the tooth scored and wheel damaged, or even broken.

It seems scarcely necessary to point out that a tool started either wet or dry should be finished without change. In hand grinding dipping the partly-ground tool into water for cooling is almost sure to damage it. In wet grinding the water supply must be much more liberal than is usually allowed. The flow need not, and indeed should not, be very rapid; but the volume delivered from the nozzle must be, for ordinary grinding, enough to flood completely the tool—say from five to ten gallons per minute. A discharge area equivalent to that of a ¾-inch pipe, therefore, is none too large, and for big tools is not large enough.

Because it is possible to force high-speed tools even when dull, it is a common practice to run them longer without re-grinding than is economical—to run them, in fact, until the edge breaks down or the product passes beyond the limits of required accuracy. The maxim, "Keep your tools sharp," is as applicable in the case of high-speed as in that of ordinary tools, though the consequences of disregarding it are, perhaps, less noticeable when the tools are used in connection with the strictly modern machine tools. If used in machines not especially designed for them, the observance of the caution is a matter of great importance; otherwise, the wear on the machine and effect upon the work are very marked. Furthermore, if the tool is not ground as soon as it begins noticeably to dull, the dulling thereafter proceeds at an increasingly rapid rate on account of the machine giving under the increased strains and the consequent augmentation of the chatter, which latter is at the bottom of most of the wear or breaking down at the cutting edge. In the end, therefore, it is better to grind oftener, remove less metal per grinding, and keep tools keen. This will almost wholly obviate the need for fettling tools in



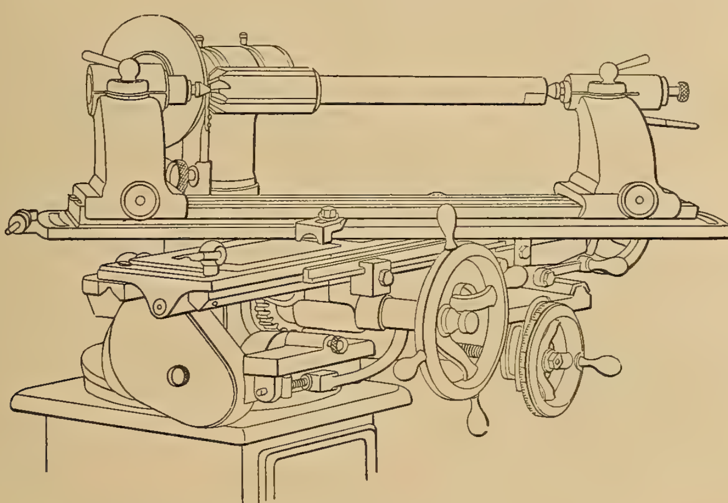
HOW THE CLEARANCE OF A DRILL INCREASES FROM THE PERIPHERY TOWARD THE CENTER

Suppose *A* and *B* represent cylinders corresponding in diameters to any two points in the cutting lip of a drill, and *c d* the feed or advance per revolution, for the sake of clearness much exaggerated. The angles made by the lines *b* and *a* then represent the clearance required at the selected points. Courtesy of Wilmarth & Mormon Company.

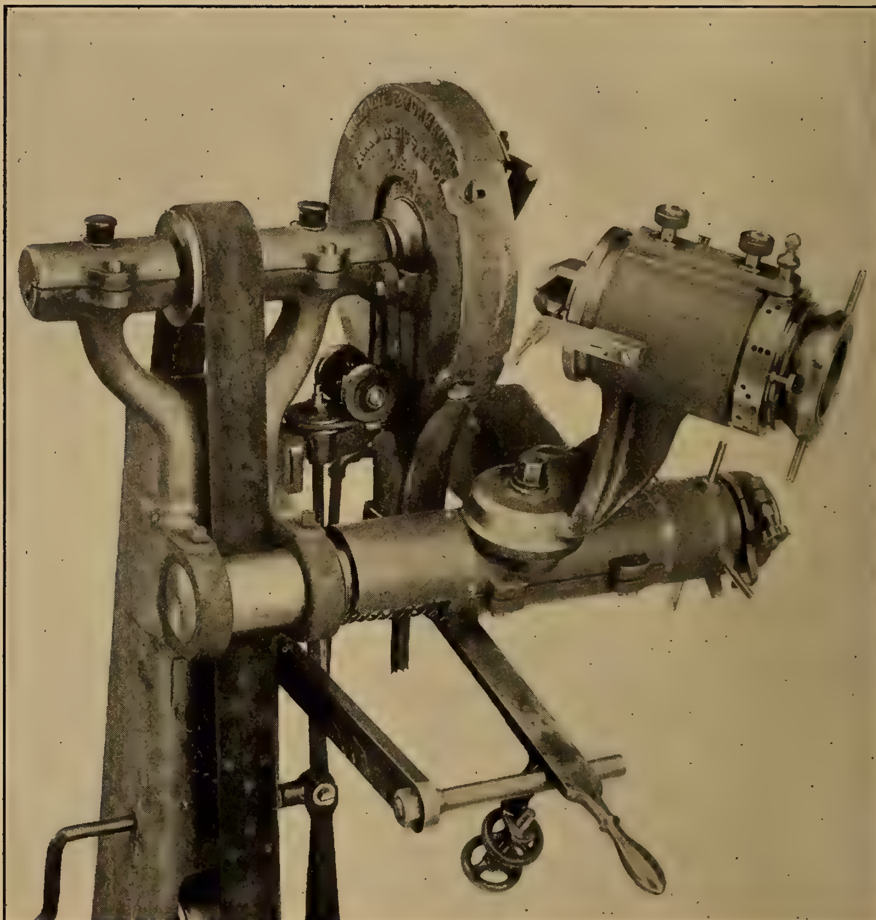
the forge shop, particularly if they have been properly designed in the first place to provide for the removal of many successive layers at the cutting and before requiring forging to shape again.

In regrinding tools, either because dulled or because of damage sustained in a previous grinding, the amount of metal removed should be commensurate with the condition of the cutting edge or tool surface. If the tool has been damaged by overheating in grinding, the part to be ground away most generally will need to be at least 1-16 inch, and may need be two or three times as deep. Checks are exceedingly difficult to discover, and usually pass unnoticed until the tool breaks down at work. Often their presence and extent can be discovered by rubbing the finished surface with petroleum, cleaning this off well, and then wiping the surface with chalk. Some oil usually will have penetrated into the minute fissures and sweats out directly, making them more or less discernible. When redressing a dulled tool it is desirable, for the most part, to grind both lip or face and clearance or back, most of the material removed preferably coming from the latter surface. As tools of the milling cutter type usually wear, a given depth removed from the back will give a result equivalent to that produced by removing two or three times as great a depth from the face. Grinding the back also serves to preserve perfectly the contour of the cutting periphery. The life of such cutters is, therefore, considerably prolonged.

The methods and precision here indicated as essential to economical grinding for highest efficiency imply the standardization of the tools used in a shop so far as possible, and the organization of the tool supply on a basis which relegates all grinding to a department or to departments suitably equipped for first-class work and manned by operators skilled in that especial work and trained to the observance of all details of design in particular tools, as well as the methods to be followed in the actual grinding operations. The organization of a tool supply department can be very simple, and, indeed, should be so. The prime requirements are proper equipment and operation, as stated; standard designs of tools for practically all jobs, all details for each tool being definitely determined and carefully observed; and an ample



GRINDING A ROSE REAMER ON A NORTON UNIVERSAL GRINDER



GRINDING A ROSE REAMER ON A WILMARTH & MORMON COMPANY'S SPECIAL MACHINE

This is the more economical method for doing this class of work, where great numbers of such tools are used

supply of tools, sufficient to permit machine operators to replace dull tools without loss of time. The latter are at a convenient time returned to the supply department in exchange for sharp ones. The tools are ground in batches, as these accumulate, to save too frequent changes at the grinder. The man in charge of the grinding, of course, is provided with a set of standard samples and a chart indicating the precise form and angles for each tool. This being carefully followed, the difficulties arising from hand grinding, such as varying angles, unsymmetrical cutting edges, improper breaking off and relief, and the like, are entirely absent, and tools not only work more effectively, but last a great deal longer. The fixed charges on the investment represented in such an equipment and ample tool supply are not comparable to the economy effected. The conditions, of course, apply with equal force in the case of ordinary tools; and the method of handling the regrinding, of course, would be the same for both.

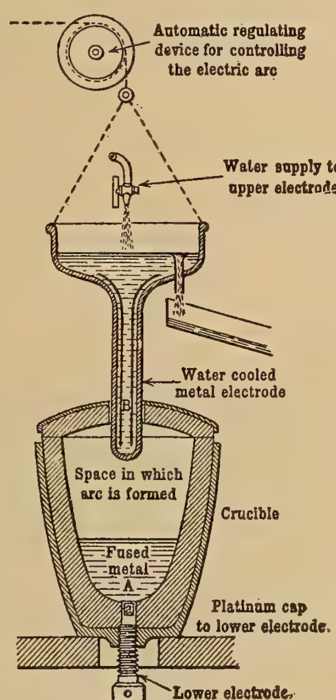
METHODS OF REFINING STEEL IN THE ELECTRIC FURNACE

By John B. C. Kershaw

THIRTY years have passed since the late Sir William Siemens, of London, showed that it was quite practicable to melt iron or steel in a crucible by aid of the electric arc, and that this method of melting steel would not be excessively costly. He also prophesied that at some date in the future the use of electricity as an agent of heat would become of great importance in the iron and steel industry. The illustration on this page is a sectional elevation of the crucible patented by Siemens for this purpose, and it represents, so far as the writer is aware, the earliest attempt to apply electricity in the manufacture of iron and steel.

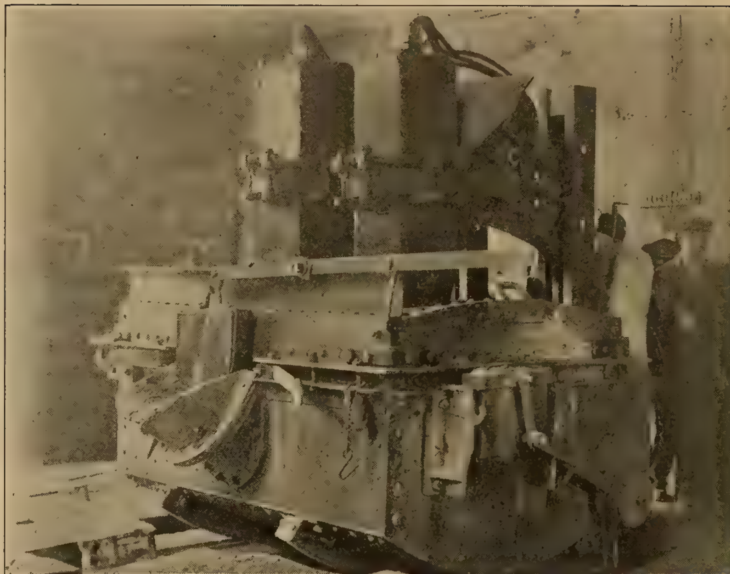
For quite twenty years Siemens' ideas and proposals lay dormant, and it was not until the year 1899 that any practical attempts to develop them were made by Heroult and other electro-metallurgists. The progress during the ten years that have elapsed since the electro-metallurgist, Paul Heroult, and the Swedish engineer, F. A. Kjellin, turned their attention and inventive abilities to this subject has, however, been rapid, and to-day the use of the electric furnace for the production not only of special steels, but also of rail and structural steels, has passed far beyond the experimental stage of its development. In a few years more Sir William Siemens' prophecy of 1879 will be completely realized, and the greater number of steel works will possess electric-funace refining plants for the production of special tool and other steels.

Readers of Cassier's Magazine who have not followed the recent developments of the electric-furnace methods of steel refining will be surprised to learn that there are already between thirty and forty of these plants in actual operation. This total is certain to be increased during the year 1909, as many additional firms are negotiating for licenses to oper-



SIEMENS ELECTRIC CRUCIBLE FURNACE

ate the furnaces and processes. The greater number of these installations are equipped with the Girod, Heroult or Kjellin type of furnaces, or with the latest modifications of these, and the following list of thirty-one firms who are working these furnaces, under licenses from the companies con-

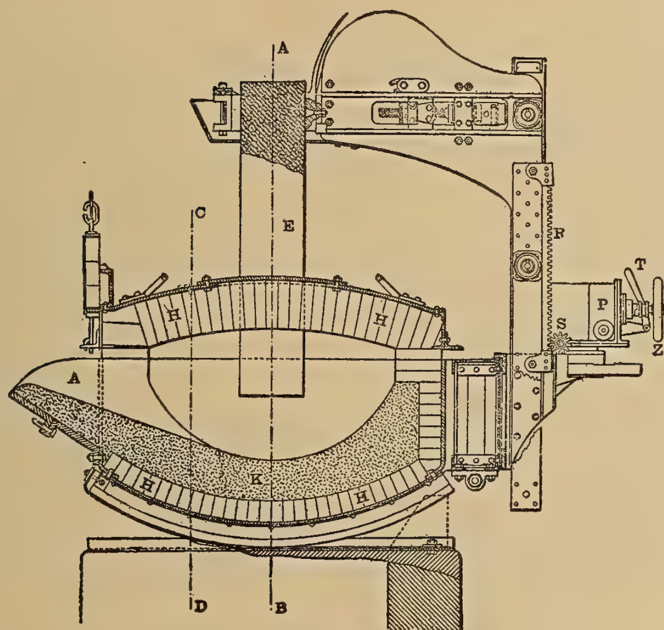


THE HEROULT ELECTRIC STEEL CRUCIBLE FURNACE

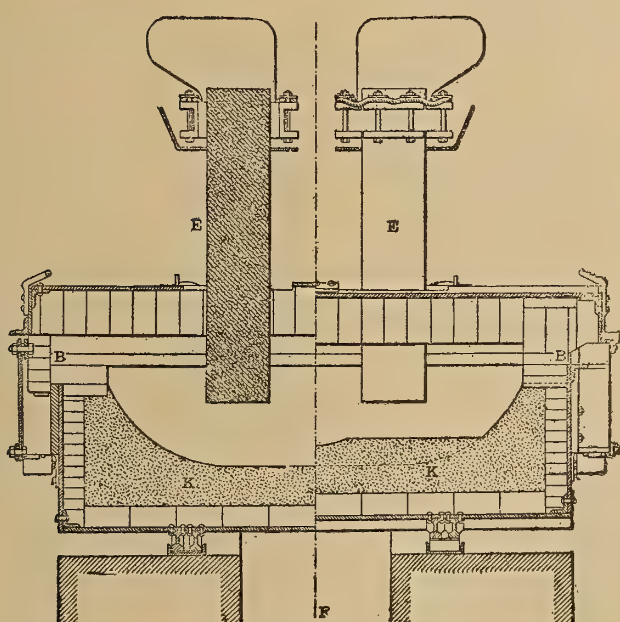
trolling the patent rights, shows how widely the electric-furnace method of steel refining has extended. (The furnaces and processes are being worked in addition at several places in Europe by the companies owning the patents.)

Heroult Furnaces. — Kaernthner Eisen and Stahl Werke, Austria; Deutsche Mannesmann-röhren Werke, Saarbrucken, Germany; Deutsche-Oesterreicheische Werke, Burbach, Austria; Societa Tubi Mannesmann, Dalmine, Italy; Oberschlesiche Eisen-

HEROULT CRUCIBLE FURNACE DISCHARGING

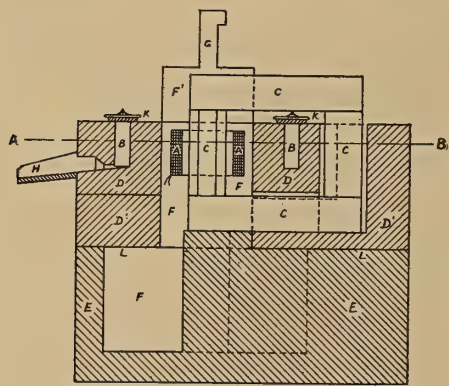


TRANSVERSE SECTION OF HEROULT CRUCIBLE FURNACE

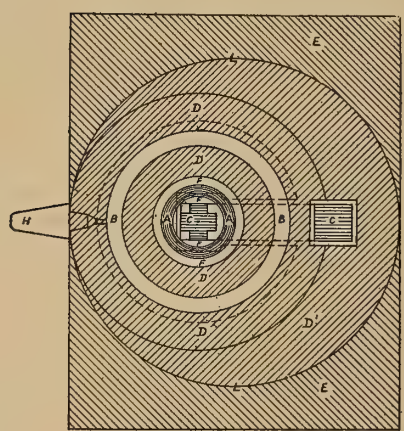


LONGITUDINAL SECTION OF HEROULT CRUCIBLE FURNACE

industrie, A. Gesellschaft, Bismarkhutte, Germany; The Firth-Sterling Steel Company, McKeesport, Pa., U. S. A.; Danner & Co., Judenburg, Austria; Stahl-werke Richard Lindenburg, Remscheid-Hasten, Germany; Georg Fischer, Schaffhausen, Switzerland; Edgar Allan & Co., Sheffield, England; Geb. Bohler & Cie., Kapfenburg, Austria; Acieries du Saut-du-Tarn, St. Juery, France;



SECTION OF KJELLIN FURNACE



PLAN OF KJELLIN FURNACE

Halcomb & Co., Syracuse, N. Y., U. S. A.

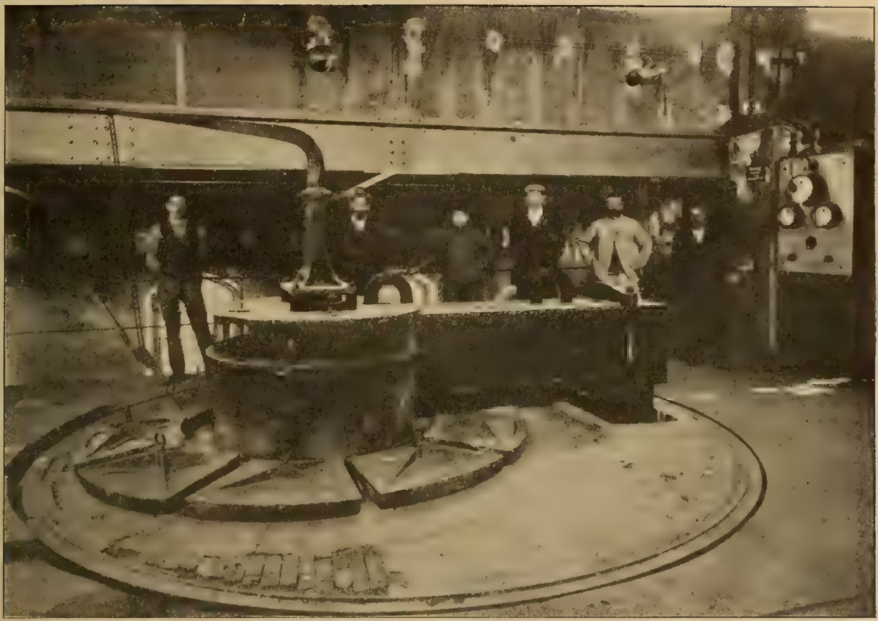
Kjellin & Röchling Rodenhausen Furnaces.—La Gallais Motz & Cie., Dommeldingen, Luxemburg, Germany; Fried. Krupp, Essen, Germany; Oberschlesche Eisenindustrie A Gesellschaft, Gleiwitz, Germany; Poldihutte, Kladno, Austria; J. Brauns Sohne, Voeklebruck, Switzerland; Allg. Calciumcarbid Gesellschaft, Gurtnallan, Switzerland; Vidua de Urigoita e Hija, Araya, Spain; Alti Forni Gregorini, Lovere, Italy; Vickers' Sons & Maxim, Sheffield, England; Röchling, Voeklingen, Germany; Borgische Stahlindustrie, Remscheid, Germany; Acieries Liegoises, Liege, Belgium; J. Knopfel, Welzenhausen, Switzerland.

Girod Furnaces.—Ochler & Cie., Aarau, Switzerland; Joh. Cockerill, Seraing, Belgium; A. Stortz, Stuttgart, Germany; Schoeller & Cie., Ternitzer Eisen & Stahl-werke, Ternitz, Austria; Marrel Freres, Rive-de-Cier, France.

In the following pages the writer will give a detailed description of the construction and principles of the furnaces named above, with some information relative to the power consumption and quality of the steel produced. The application of the electric furnace to iron smelting will not be touched upon, as this branch of the subject has not yet emerged from the experimental stage of its development.

THE HEROULT FURNACE AND PROCESS

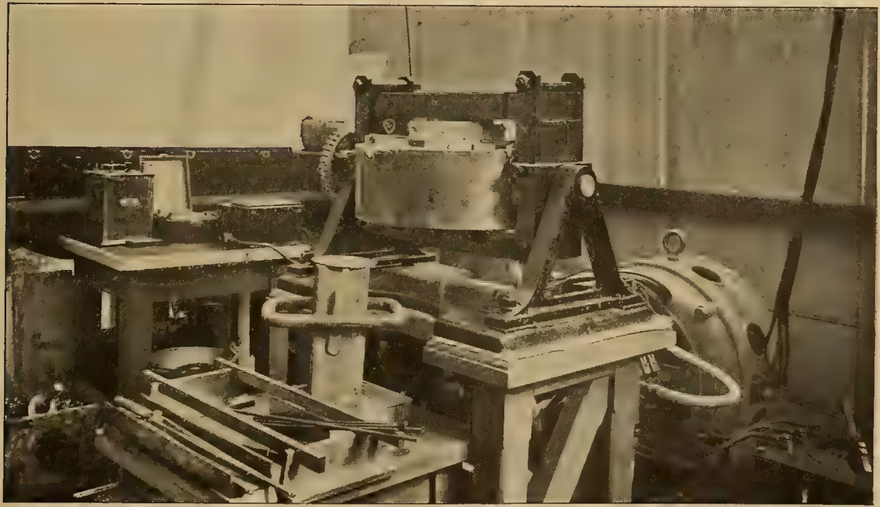
The Heroult furnace for steel refining is a tilting furnace of the crucible type, and is operated with combined arc and resistance heating. The refining operation is, in fact, a "washing-out" of the impurities of the iron by treatment with suitable slags. The furnace proper consists of a closed shallow iron tank thickly lined with dolomite and magnesite brick. The hearth is formed of crushed dolomite. On page 239 are shown cross sections of the furnace. The electric current is carried by the two massive solid carbon electrodes shown. These electrodes are 70 inches in length and 14 inches in diameter, and are mounted in such a manner that they can be moved either vertically or horizontally by the electrician controlling the work of the furnace. In the latest furnaces the electrodes are water jacketed, in



KJELLIN FURNACE AT GYSINGE

order to reduce their rate of consumption. At the opposite side of the furnace from the discharge lip there is an inlet for the air-blast, while openings are provided in the cover of the furnace for charging the raw materials, and for the escape of the gases produced on heating the charge. The method of refining steel in this furnace is as follows:

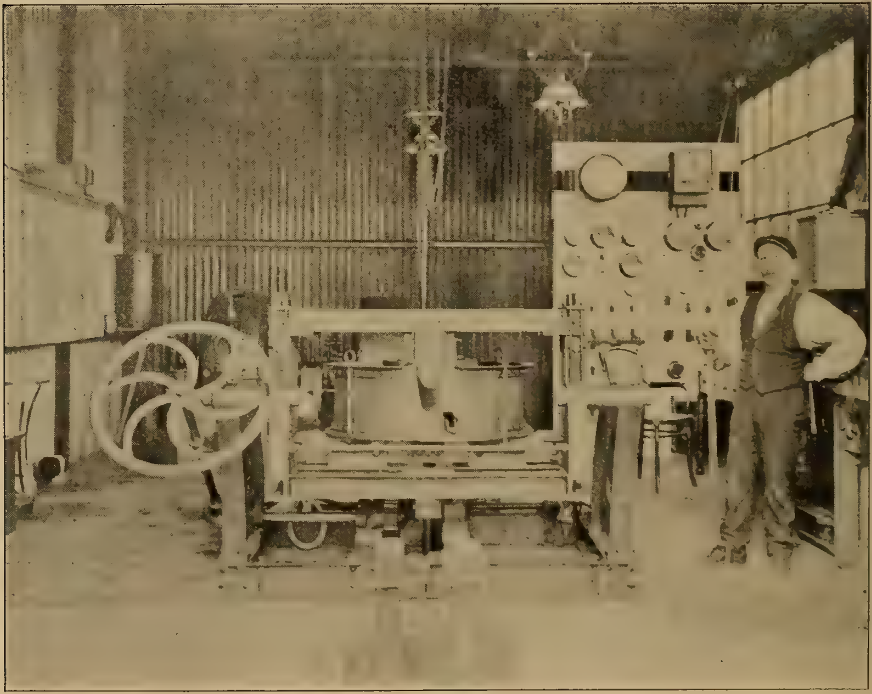
The charge, consisting of steel scrap, pig iron, iron ore and lime, in suitable quantities and proportions, is placed on the hearth of the furnace, and is raised to the melting point by combined arc and resistance heating,



KJELLIN FURNACE AT SHEFFIELD, CONSTRUCTED BY VICKERS SONS & MAXIM, LTD.

an alternating current of 4,000 amperes at 120 volts being utilized, with a 3-ton furnace, for this stage of the process. The lime and silicates of the ore form a slag which fuses readily and spreads over the surface of the molten iron and steel, thus protecting it from the action of the liberated gases, and of the oxygen of the atmosphere. The electrodes are now lowered until they just dip beneath the surface of the molten slag and the further heating of the charge occurs by resisting heating alone—the molten slag and the metal beneath it carrying the 4,000 ampere current from one electrode to another. In order to oxidize those impurities of the metal which it is most necessary to remove, an air blast is caused to enter the furnace through the apertures provided for the purpose, and in this way the sulphur and phosphorus are oxidized and are carried into the slag. The furnace is now tilted for the purpose of removing this slag and the treatment is continued two or more times with fresh quantities of lime, etc., until a comparatively pure metal is left on the heart of the furnace. When this point is reached a calculated amount of an alloy high in carbon (carburite) and of whatever other constituent is desired in the finished steel is added to the molten mass, and the charge is then tipped into the casting ladle. The Heroult crucible furnaces produce, as a rule, three tons of steel per charge, and the time required varies from eight to ten hours. The phosphorus is reduced to .009 per cent. and the sulphur to .008 per cent., these figures being the average of 743 charges. One of the test runs made by the Canadian Commissioners at La Praz with the Heroult crucible furnace gave the following results:

CHARGE	Pounds
Scrap iron	3,307
Iron ore	330
Lime	246
Lime	55
Yield	2,829
SECOND SLAG	
Sand, pounds	15.5
Fluor spar, pounds	15.5



60-K.W. EXPERIMENTAL KJELLIN FURNACE IN LONDON

GENERAL VIEW OF THREE-PHASE AND SINGLE-PHASE RÖCHLING-RODENHAUSER INDUCTION FURNACES. THE GRONDAL KJELLIN COMPANY, LTD.

THIRD SLAG	
Sand, pounds	15.5
Fluor spar, pounds	15.5
FINAL ADDITION	
Ferro manganese alloy, pounds	1.5

Electrical power. — 1,410 kilowatt hours equal to 153 electrical horse-power year, per 2,000 pounds of finished steel.

The above was a dead, soft steel and had the following composition: Carbon, .079 per cent.; silicon, .034 per cent.; sulphur, .022 per cent.; phosphorus, .009 per cent.; arsenic, .096 per cent.; manganese, .230 per cent.

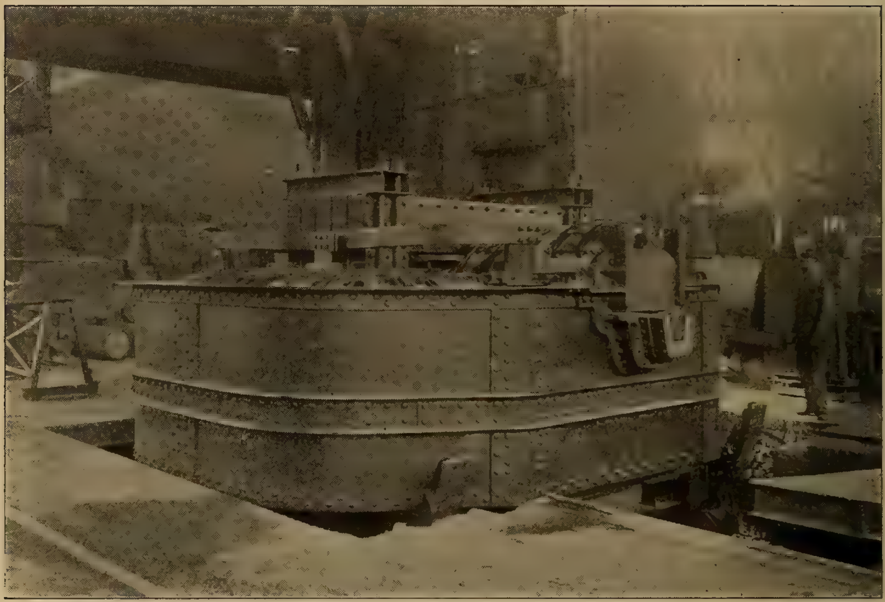
A second trial run, with a larger charge, yielded 5,161 pounds of a hard tool steel, of the following composition: Carbon, 1.016 per cent.; sulphur, .02 per cent.; silicon, .103 per cent.; phosphorus, .009 per cent.; arsenic, .06 per cent.; manganese, .150 per cent.

The electrical power required in this case was 2,580 kilowatt hours, equal to .153 electric horse-power year per 2,000 pounds of steel.

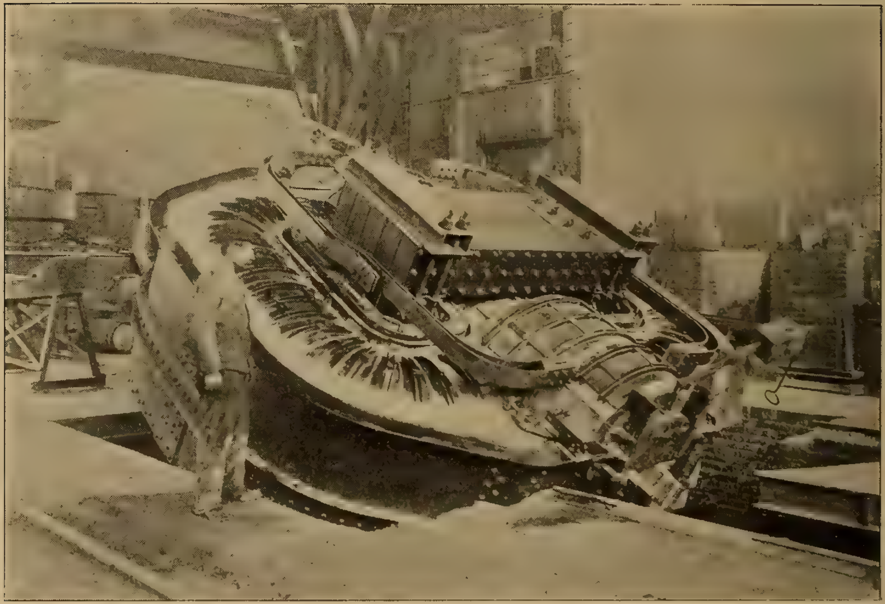
THE KJELLIN & ROCHLING FURNACES

When an alternating current of electricity flows through a conductor a similar current is set up in any neighbouring conductor, and this latter is called an "induced" current.

This principle is made use of in the Kjellin and Röchling Rodenhauser furnace—the metal to be heated, forming the secondary circuit, of what is really a large and novel form of transformer. On page 240 a sectional elevation and a plan of the original Kjellin type of induction furnace, erected at Gysinge, in Sweden, in 1901, are shown. This furnace consists of a transformer, the core of which is shown at *C C*, the primary coil at *A A* and the secondary circuit of which is supplied by the molten metal contained in the circular channel. The current obtained in the metal is roughly that of the primary multiplied by the number of turns in the coil. The emptying of the furnace was originally effected by making a hole in the wall—but tilting furnaces of the induction type are



EIGHT-TON RÖCHLING-RODENHAUSER INDUCTION FURNACE IN NORMAL POSITION. THE GRONDAL KJELLIN COMPANY, LTD., LONDON



EIGHT-TON RÖCHLING-RODENHAUSER INDUCTION FURNACE TILTED FOR TEEMING

now constructed—while the fresh charge is distributed equally round the furnace ring by removing the covers shown at *K K*. As the secondary circuit of this furnace can only be operated with molten metal, it is never entirely emptied, only one-half of the finished charge being poured at each casting, and the fresh scrap, etc., being added to the molten metal which remains in the circular ring and still carries the induced current.

The above steel had the following composition: Carbon, 1.082 per cent.; silicon, .194 per cent.; sulphur, .008 per cent.; phosphorus, .010 per cent.; arsenic, .012 per cent.; manganese, .240 per cent.

A second trial run, with a fresh charge of 1,061 kilogrammes, yielded 955 kilogrammes of steel on tapping the furnace, the run lasting six hours, and the finished steel testing as follows: Carbon, .01 per cent.; silicon, .145 per cent.; sulphur, .008 per cent.; phosphorus, .01 per cent.; arsenic, .020 per cent.; manganese, .110 per cent. The electrical energy required in this case was equivalent to .154 electrical horse-power year per metric ton.

THE RÖCHLING-RODENHAUSER INDUCTION FURNACE

The following details of runs with the 1,800 kilogramme Kjellin furnace at Gysinge are from the Canadian Commissioner's report:

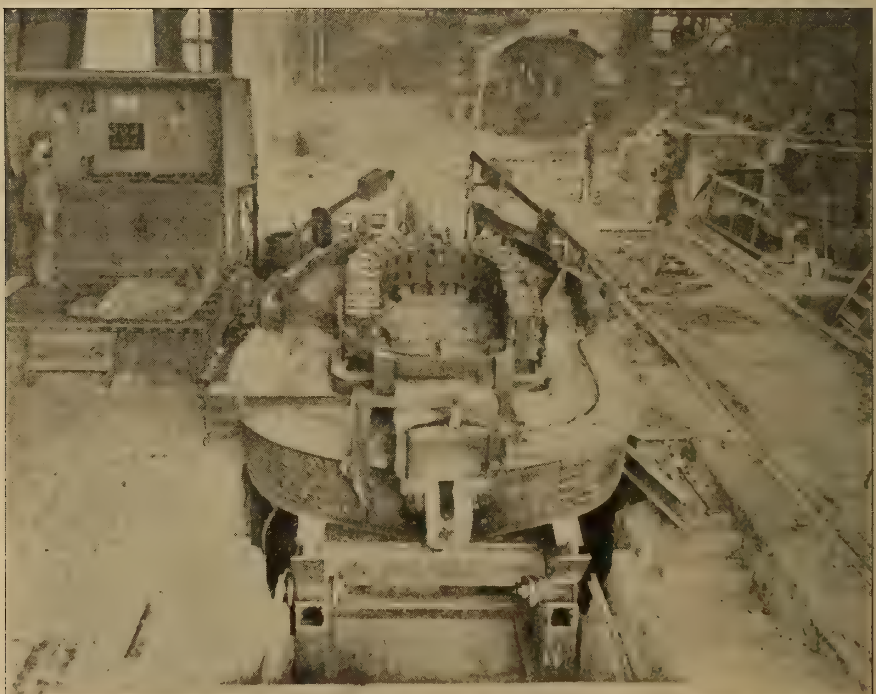
CHARGE	Kilogrammes
Pig iron	300
Steel scrap	125
Bar scrap	600
Silicon pig	30
Ferro manganese	1
Metal in furnace	700
Total weight	1,756

Yielded 1,030 kilogrammes steel in six hours.

Electrical power consumed: 857 kilowatt hours, equal to 133 electrical horse-power year per metric ton (2,204 pounds) of finished steel.

The raw materials used in the Kjellin furnace and process have to be of a high degree of purity, since the temperature attained in it (about 1,600 degrees to 1,700 degrees C.) is too low to admit of the elimination of the impurities, as in the Heroult crucible furnace, and this restriction

of its field of usefulness has prevented its adoption in many cases. In order to overcome this defect of the original type of Kjellin furnace, a modification has been designed and patented by Messrs. Schönawa and Rodenhauser, two German electrometallurgists. The modified furnace has the form of the figure 8, and consists of two Kjellin furnace rings, meeting together and forming a wide centre trough, in which the metal is subjected to ordinary resistance heat which passes from end to end of the trough. According to Engelhardt, the chief gains of this form of construction are metallurgical in character, although the electrical efficiency of the furnace is stated to be rather higher than that of the simple Kjellin type. The chemical changes which depend upon a high temperature for their completion are carried out in this central zone of the furnace, and the elimination of the impurities of the raw materials of the



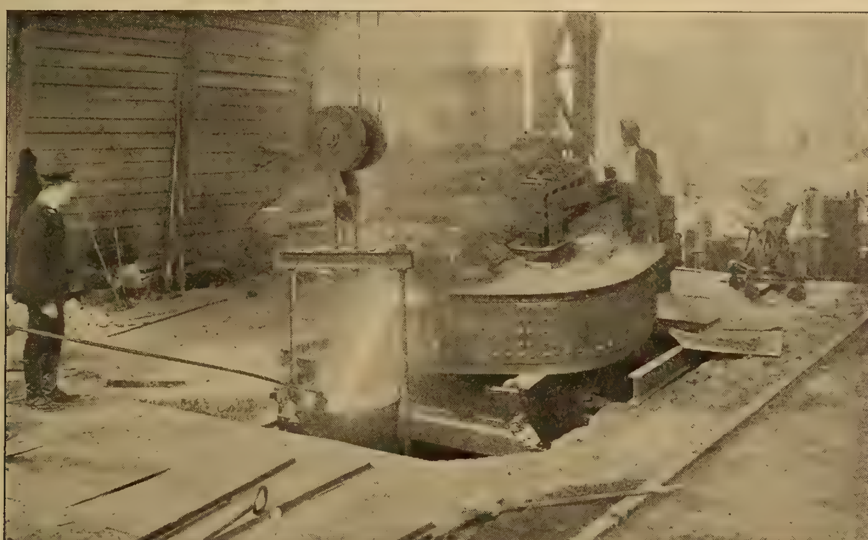
ANOTHER VIEW OF A RÖCHLING RODENHAUSER INDUCTION FURNACE

by direct or alternating currents. On page 248 is shown the plan of this form of construction. The annular rings holding the metal are built up around each leg of the transformer, and these meet, as shown, in the centre, to form a wide trough common to the loops of the complete figure 8. The central trough of the furnace is provided at its ends with iron plates, covered with a thick layer of graphite and magnesite, and these act as terminal electrodes for the current charge by methods similar to those employed in the Heroult furnace is said to be possible by use of the Schönawa-Rodenhauser modification of the Kjellin furnace.

Little or no action occurs on the electrode plates, and in one case these had been in use for three months without any appreciable losses due to corrosion. The slag is confined to the centre part of the furnace, and is not allowed to enter the annular rings; and the linings of the latter

are, therefore, not subjected to the destructive action of the molten slag. The following account of the method of working this furnace is given by Harden, in a paper read before the Faraday Society on June 23, 1908. The iron is charged into the furnace from a Bessemer converter, it being found more economical to burn out the carbon and silicon in the converter before eliminating the sulphur and phosphorus in the electric furnace. Calcined lime, fluorspar and plate scale from the rolling-mill are then added, in the proportions ascertained by experience necessary to form a liquid slag. In this condition the slag takes up the phosphorus very readily; by addition of a little fresh lime it is made viscous and fit for drawing off the charge of metal through the slag door, the furnace being tilted for this operation. The operation is repeated with fresh slagging materials if necessary. As soon as the elimination of the phosphorus is complete, ferro silicon or carbon is added to remove the oxygen, and a fresh slag of lime is formed. This acts as a desulphurizer, iron sulphide being formed, which passes into the molten slag. The slag is removed, as before, by tilting the furnace, and the temperature of the remaining molten metal is then raised to a maximum point, in order to drive out the last traces of occluded gases. As a rule, refining operation, when using oxidized metal from the converter or open-hearth furnace, can be finished in from 1¼ to 2 hours; and the power consumption in this case is very low, being only from 125 to 150 kilowatt hours per ton of finished steel.

A metal containing .101 per cent. phosphorus and .10 per cent. sulphur can be treated in this manner, and a product containing only .06 per cent. phosphorus and .03 per cent. sulphur obtained, especially distinguished by its strength and homogeneous structure. It is a fact that rail-steel has been made in this type of furnace having a much higher bending and breaking limit than ordinary Bessemer or Thomas rail-steel, and that these rails in Germany have commanded a price 25*s.* to 45*s.* per ton higher than that of ordinary rail-steel. Furnaces of this type of 8 tons capacity have been erected at the Röchlingsche Gun & Steel Works at Volklingen, in Germany, where the

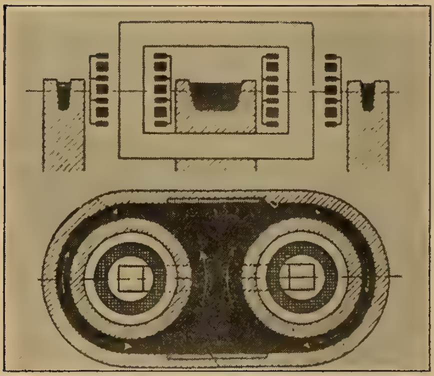


RÖCHLING-RODENHAUSER THREE-PHASE INDUCTION FURNACE DURING TEEMING

furnace was first tried, and over 2,000 tons of rails made from the product of the new type of furnace have been delivered to the Prussian Government. A further 5,000 tons was ordered during 1908 from the Röchlingsche Iron & Steel Works for the Italian and Swiss Governments. The photographs are of the two-phase Röchling-Rodenhauser furnace at that works.

THE GIROD FURNACE

This furnace is the outcome of the work of M. Paul Girod, of the large and important factory for the manufacture of ferro-alloys at Ugine, in France. In principle the furnace is similar to the Heroult crucible furnace, both arc and resistance heating being employed for fluxing and refining the charge.



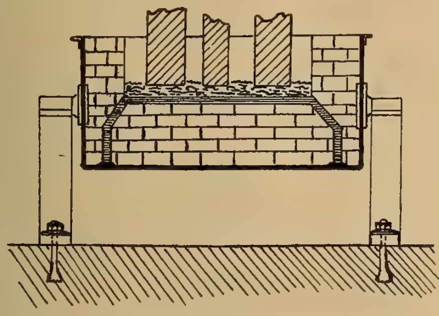
SECTION AND PLAN OF THE RÖCHLING-RODENHAUSER FURNACE

The details of construction, however, differ widely from the Heroult furnace, and are shown on page 249, which represent the earliest type of furnace. The furnace consists of a circular sheet-steel casing mounted upon trunnions and thickly lined with magnesia brick. The bottom of the furnace is formed by a number of water-cooled plates of cast iron embedded in the brickwork and connecting with the cavity of the furnace by canals left in the brickwork lining. The cover of the furnace is formed by a dome of silica brick, through which pass four solid carbon electrodes suspended from chains. When operating the furnace the canals are first filled with molten pig-iron, and the charge of scrap and pig-iron with suitable fluxing materials is placed in the cavity of the furnace proper. The melting and purification of the charge proceeds as in the Heroult furnace, alternating current only being employed. The electrodes are worked in parallel, and the current passes through the slag

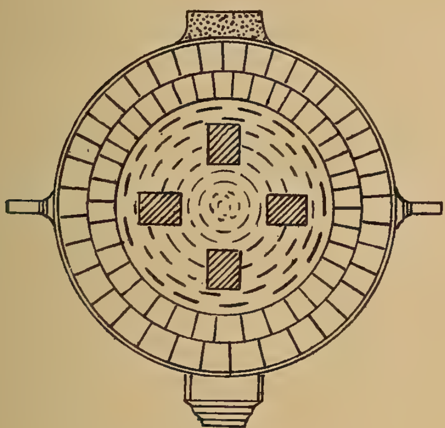
ETCHED SECTION OF AN ELECTRIC STEEL RAIL

ETCHED SECTION OF A THOMAS STEEL RAIL

and molten metal in the furnace chamber canals to and from the base electrodes of the furnace, and not horizontally, as in the Heroult fur-



SECTIONAL ELEVATION OF THE GIROD FURNACE



PLAN OF THE GIROD FURNACE

nace, from one electrode to the other. The methods of working the furnace and of eliminating the phosphorus and sulphur are, however, much the same as in the Heroult furnace, and it is not necessary to give details here.

Girod has stated that, at Albertville, one ton of steel has been produced in this furnace in four and one-half hours, with an expenditure of 1,060 kilowatt hours of electrical power. The advantage of the Girod furnace over the Heroult type is the easier regulation of the arcs, all the electrodes in the crown of the furnace being of one polarity. A lower electromotive force can also be employed, since there is only one arc in the path of the current as compared with two in the Heroult furnace. In the latest form of Girod furnace the construction of the base of the furnace is slightly modified. Soft steel blocks are embedded in the hearth, and are themselves in direct contact with the molten metal of the charge, the intermediary canals being dispensed with. The lower ends of these pole pieces are water-cooled; and although there is a tendency for the upper ends to become molten, the amount of metal lost from this cause is negligible. When working with cold scraps of impure composition the power consumption of the improved Girod furnace is about 900 kilowatt hours per ton of refined steel. This figure can be reduced to 350 kilowatt hours if molten metal from a Bessemer converter or from an open-hearth furnace be employed for charging the electric furnace. On account of the possibilities of attaining very high temperatures in the furnace, raw material of any degree of impurity may be refined in the Girod furnace.

ELECTRIC DRIVING FOR WEAVING MACHINERY

By Albert Walton

APPLICATIONS OF INDIVIDUAL ELECTRIC MOTORS TO THE DIRECT OPERATION OF LOOMS.

It is probable that the operation of a loom by a direct-connected electric motor is one of the most difficult problems in electric driving. How successfully it has been accomplished is shown by Mr. Walton in this paper, a record of the result of patient work in the face of many obstacles. If the electric motor can be used satisfactorily for this work, it would seem as if there is no department of machine operation to which it may not be successfully applied.—THE EDITOR.

MACHINISTS have so long been accustomed to consider the driving of a single machine by a single motor as the accepted and recognized ideal in driving that many have forgotten the great uphill fight that was made by the believers in it through hard years of trials and tribulations, against the opposition of manufacturers and the prejudice of the machinists themselves. It is interesting to know that a very similar development is now in progress in another line, and, though the opposition and prejudice are manifested in no less degree, the victories of its advocates are just as convincing as they have been in the machine shops. Individual driving of textile machinery is comparatively a new idea in the United States. It is only within the last two or three years that motors suitable for this work have been available at prices which make it possible to apply them to the light-running machines of textile mills. When, however, such motors became available, a double task awaited the manufacturers, who, knowing the characteristics of their motors and backed by their successes in other fields, set out to develop the field commercially.

In the first place, it was necessary to study the requirements thoroughly and to produce motors exactly fitted for the work. The second and harder tasks lay in convincing the mill men of its superiority and inducing them to adopt it.

That the double task has been accomplished to so large an extent in so short a time is *prima facie* evidence that the merits of the new system were real and pronounced, for there is no more conservative and practical guild of manufacturers the world over than the spinners and weavers of cotton and worsted yarns. To enter a modern mill which is the direct outgrowth of the original old stone mill built on the same site a hundred years before and to proclaim to the grandson of the founder of that first mill that there is something new under the sun, and to convince him of it by demonstration, so that he buys and buys again—that is a test of merit. Yet there are mills in old New England where, were you able to pass the ever-alert cordon of watchmen, you would find looms, spinning frames, fly-frames, printing machines, mangles, calenders, each with its own motor operated by the usual help and producing yarn or cloth of better quality and in greater amount than is done with the century-old method of our forefathers.

It is rather strange that the last process in the mill was the first one to demonstrate the advantages of this new drive. There are at present more individual motors on looms than on the preparatory machines. This is partly due to the fact that a great deal of work had been done in Europe in this field to meet the peculiar conditions which exist where each peasant or villager has a loom

or two in his home for the wife and daughter to work on during the day. The only way to drive an isolated machine of this sort was by electric power through an individual motor. Thus when the development was begun in America it naturally followed the lines of least resistance and began with the loom.

The nature of the work performed by a loom would make it appear remarkable that motors should be applied first to this machine except in the light of these facts. The loom is practically the only reciprocating machine in a textile mill, all the other machinery being distinctly rotary and mainly operated at high speed. Two reciprocating sections are essential in weaving. The shuttle must be thrown from side to side, and the thread left in the wake of the shuttle must be moved into position as one of the crosswise threads in the cloth. When it is considered that the shuttle passes from end to end of the loom from two to three times a second, and that the thread must be moved into place between trips, some idea of the rapidity of modern weaving may be had.

The operation is simple enough. The warp, or lengthwise thread of the cloth, is mounted on a huge spool at the back of the loom. This spool or "beam" may carry 1,000 to 5,000 threads, each of which is from 500 to 1,500 yards long. The threads are passed forward to the front of the loom. On the way they are threaded through the eyes of two frames, which are arranged to move alternately up and down. Every alternate thread passes through the eyes of one frame, or harness, and the remainder pass through the other. The harnesses are arranged on a rocker device, so that when one is up the other is down, the travel being about 7 inches. After the threads have been run through these harnesses they pass through a comb or "reed" on the reciprocating part of the loom. One thread passes between each two teeth. There is a track just in front of this comb on which the shuttle travels. At each end of the track is a box, one side of which is held in place by a spring. The shuttle is wedged into the box against the pressure of this spring, and the loom is ready to start (see Fig. 1). One harness being up and the other down, every alternate thread is raised and every other one lowered. The reed, with its shuttle track and boxes, is in its furthest back position, so as to be as near the harnesses as possible, for here the distance between the raised threads and the lowered threads is greatest and there is most room for the shuttle to pass. The shuttle is then shot through the "shed" thus formed and leaves in its trail one thread, which runs freely off the bobbin contained in the shuttle. The reed is then moved forward, pushing this thread up to the finished cloth, of which it then becomes a part (see Fig. 2). At the same time the harnesses reverse their position and raise the threads that were down and lower those that were above, and the shuttle is shot back again through the new shed so formed (see Fig. 3). Thus the threads which were over the one left by the shuttle on its first trip are under that left on the second trip, and so on. This process is done so rapidly the shuttle must travel at the rate of nearly a mile a minute each trip it makes.

In order to prevent damage to the threads or to the loom an arrangement is made whereby the loom stops instantly if the shuttle fails to get into the box at the end of its trip across the loom. In addition to this, the loom will stop if the thread in the shuttle breaks or runs out, or if any one of the thousand threads in the warp should break. As the thread in the shuttle is used up once in two or three minutes, the stops are extremely frequent. A device has been in use for several years which automatically refills the shuttle or supplies a complete new shuttle as desired, when this occurs;

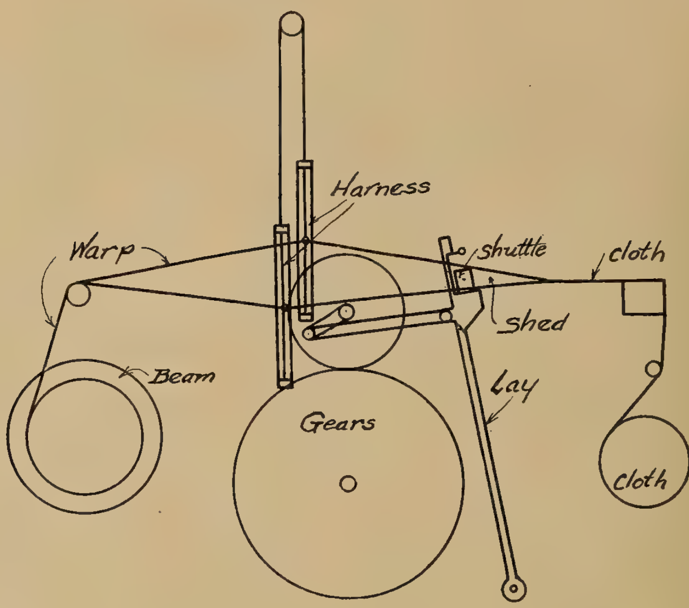


FIG. 1.—OUTLINE OF LOOM MECHANISM

Shuttle at near end of lay in position for "pick," which sends it through "shed" formed by warp threads above and below. Shuttle-throwing device not shown. Note position of harnesses. Every alternate warp thread passes through one harness, the remainder through the other harness. Thus each harness lifts half the warp.

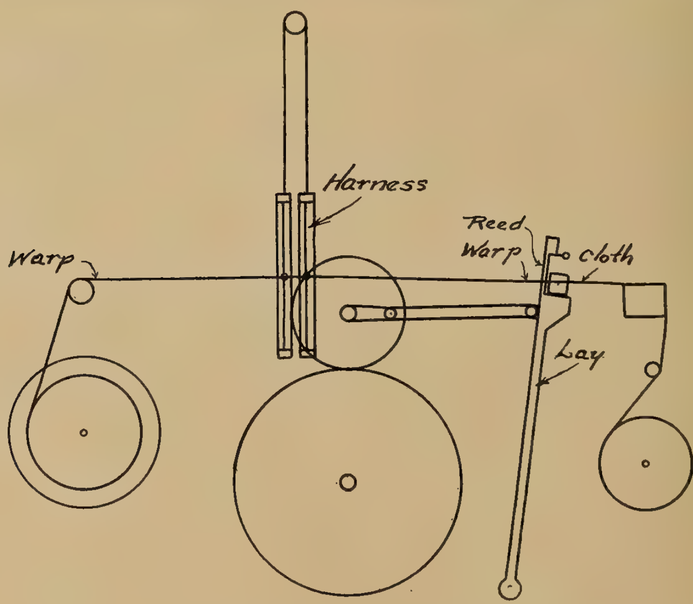


FIG. 2.—OUTLINE OF LOOM MECHANISM

Lay in forward position, forcing the thread left by the shuttle into position as one of the crosswise threads of the cloth. This is done by the "reed," which is a fine comb on the lay. One thread of the warp passes through each space of the reed.

Harnesses are just passing each other in their exchange of position.

but the ordinary loom is not so equipped, and the change must be made by hand. This is done in from ten to fifteen seconds by the usual skilled operative. In the meeting of the difficulties incident to this continuous stopping and starting lay the greatest problem in applying the single motor to the loom.

The mill conditions of atmosphere and labour, too, had to be met successfully. Owing to the incessant see-sawing of the warp threads up and down past one another, an immense amount of lint and dust is set free. The motor must work in this dust not only successfully, but without fire risk, for this lint is as inflammable as gunpowder. The motor also had to be fool-proof and require no attention. Furthermore, it had to replace the old belt drive without introducing new features for the weaver to learn. There must be no change in the weaver's work whatever.

Looms in their present form have been built for a hundred years. Long periods of close competition have reduced them to their lowest terms. They are built to do the work required of them and no more. It, therefore, was necessary to apply motors without adding in the least to the strains in the loom, which were already all that could be borne. For this reason it was not feasible to gear the motor rigidly to the loom. The momentum of the motor turning at one thousand revolutions per minute was too great to be absorbed instantly without danger to loom, motor and gears.

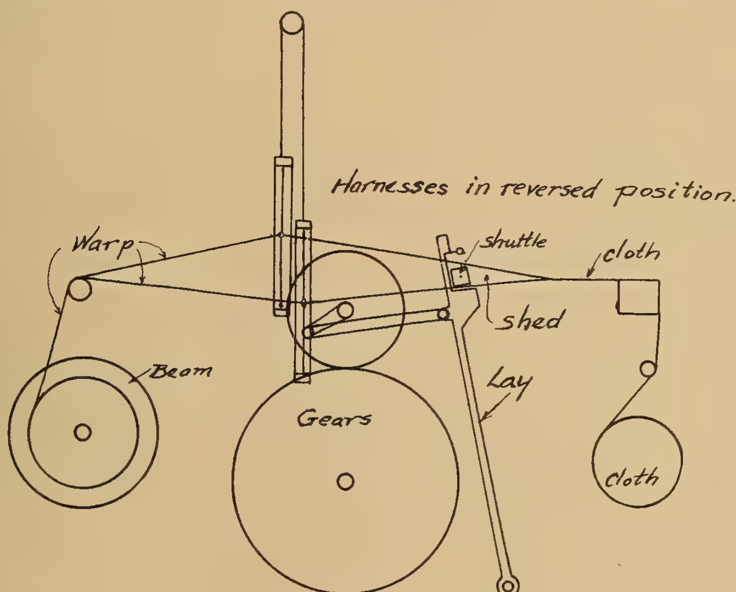


FIG. 3.—OUTLINE OF LOOM MECHANISM

Shuttle at far end of lay in position for return trip through shed. Note that threads which were above in first position are now below, and vice versa. This is accomplished by reversal of harnesses.

On account of the percentage of time during which the loom is shut down from one cause or another, it was very desirable to stop the consumption of power by cutting the motor off the circuit during these idle periods, even if they were of only a few seconds' duration each. This introduced the problem of starting the loom instantly by starting the motor and loom together from rest.

It is, as has been stated, of prime importance that the shuttle, after its travel across the loom, shall go "home" in the box ready for the next throw, or "pick" back in the opposite direction. This is as important on the first pick as any other. The loom must, therefore, be started with sufficient rapidity to ensure the shuttle's being thrown across the first time so as to jam hard into the opposite box. This means that the loom must be brought to speed from rest in about one-half a second—a severe test of the starting powers of any drive. Failing to do this, the loom will automatically shut down instantly before the completion of its first cycle of operation.

All this is accomplished by the old belt drive in two ways—by an ordinary tight and loose pulley with a belt-shifter, or by a pulley with one flanged side arranged as a friction surface, the entire pulley being moved about an eighth of an inch to press against a cork or leather disc to start the loom and being disengaged upon its stopping. Either of these devices is worked from a "shipper handle" at the operator's right hand, and either is also worked automatically by the stop-motion devices upon the breaking of a thread or the failure of the shuttle to jam in the box. The belt from the tight and loose pulleys or from the friction pulley runs from a driving shaft either overhead or under the floor. The overhead drive is an objectionable feature for many reasons. The belts are so numerous as to interfere with the supply of light from the windows or lamps. They carry dust to the ceiling, where it collects in quantities and falls into the work. They generate bothersome frictional electricity. They are always subject to a slippage because of the lint gathering on the running face, and because they are vertical belts from small pulleys. The shafting being over the work means constant trouble from dropping oil upon the woven goods.

With shafting under the floor, it means very short centers, with consequent high belt tension and frequent readjustment, to prevent slipping. It also necessitates large holes in the floor for the passage of the belts, and this is undesirable from the point of view of the fire underwriters. These points, in addition to the usual troubles incident to maintenance of alignment and cost of power wasted in friction in long lines of shafting, make it rather easier to show a mill man that individual drive is, after all, a consummation devoutly to be wished.

Coming to the motor itself, the first point to be decided upon was whether an alternating current or a direct-current motor should be used. The direct-current was immediately rejected, because of the cost of maintenance of so many small commutators and brushes, and because of the sparking and attendant fire risk incident to motors using brushes. The alternating-current motor, being brushless and sparkless, will stand indefinite use and some abuse without encountering these difficulties. It is a constant-speed motor, and, therefore, admirably suited to the work in a textile mill. This type has, therefore, been universally adopted.

In the first application of motors on looms in the United States the friction pulley device was reproduced, except that in place of the pulley with its crowned face a narrow gear with cut teeth was used. The motor pinion meshed directly into this friction gear. The motor switch was thrown in and the motor started in the morning and allowed to run till noon, started again at one o'clock and allowed to run till quitting time at night. The loom was operated just as with the belt, by moving the friction face against the disc to start and opening it up again to stop. This was very successful in increasing production, and several installations are still operating in this manner. Just why production is increased is at first hard to under-

stand, since the speed of the loom is very little increased over that at which the belt drive is figured to operate. The fact is that the motor-driven loom always operates at the speed at which it is calculated to run, which is the maximum speed the loom will stand, while the belt-driven loom always falls below this desired point, due to the slippage of the many belts between the engine and the loom.

It was found, however, that the current taken by the water running the idle gear while the loom was shut down lowered the total efficiency of drive very materially. Steps were immediately taken to develop a method which would allow the motor to stop with the loom. This involved the surmounting of two difficulties: First, the ordinary induction motor has poor starting characteristics and could not get the shuttle across on the first "pick" in time to prevent the loom from shutting off automatically; second, to stop a high-speed motor instantly through a chain of gears involved too great a strain on the gear teeth and on the entire loom structure. Gearing the motor rigidly to the loom was abandoned after the first trial. A method in use in Germany has been advanced to overcome this; but, as it makes use of a belt, it is open to the old objections to belt drive, and has not met with favour in America. In this method the motor is mounted on a hinge on a stand below the loom pulley, so that the weight of the motor comes on the belt. The jar incident to the sudden stopping was absorbed by the slipping of the small motor pulley on the belt.

American practice has indicated gear driving as decidedly more advantageous, however, and with the exception of one installation of foreign origin the belt drive has not been adopted. One thing has been learned, however, and that is that by a slight alteration from the standard designs an induction motor could be built that would start a loom properly.

In order to counterfeit the belt slip of the German method one American firm brought out a motor which has the revolving part mounted on a quill, which drives through friction discs to the shaft and pinion. When the loom stops the motor-quill slips on the shaft somewhat, thus, in a way, cushioning the shock. This has not been tried out on a large scale as yet, and it has not, there-

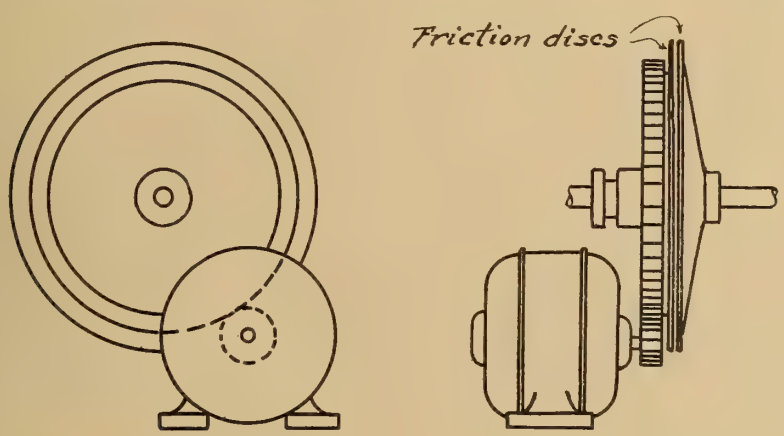


FIG. 4.—FRICTION-GEAR DRIVE

Gear attached to friction disc is pressed against disc which is keyed to loom shaft. Same motion operates motor switch. When friction is released, current is cut off. Motor starts when friction is thrown in again.

fore, been demonstrated whether or not it is subject to too much wear and will necessitate too frequent adjustment to be anything more than a theoretical solution of the problem. It is open to the objection that, to take up on the plates in compensating for the wear, the motor must be dismantled and the revolving part removed, during which adjustment loom and motor must remain idle and out of commission.

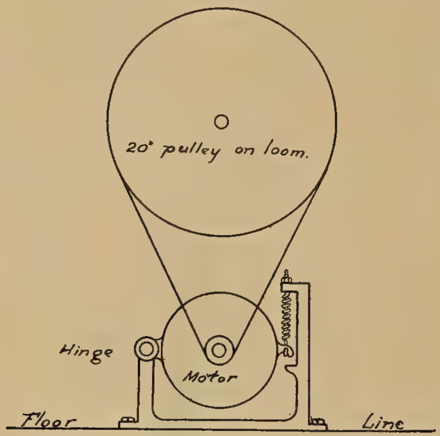


FIG. 5.—GERMAN METHOD OF DRIVE. MOTOR SUSPENDED IN BELT

Perhaps the most efficient and mechanical arrangement is, as is often the case, a compromise between the two methods. This utilizes the friction gear drive as first installed, but so arranged that the switch is opened when the loom stops, thus instantly shutting off all consumption of power. This works out very satisfactorily, for here the forces which were working against success now work for it. It is no longer necessary to absorb, and therefore lose the momentum of the motor and gear. They are cut off from the loom and the power circuit simultaneously and instantaneously, and are left free to revolve idly until brought to rest by their own friction. They will run idly thus for from thirty seconds to a full minute. As the usual stop is not over fifteen seconds, the motor is well above half speed when the friction and switch are again closed and the loom again started. The gains from this method are four-fold: (1) There is no shock to the loom, motor or gears on stopping. (2) The momentum helps to start the loom mechanically as well as by making it possible to take advantage of the excellent running properties of an induction motor at the time of severest load. (3) The electric circuit is not called on to supply the excessive current required to start an induction motor from rest, thus reducing line disturbances and motor heating. (4) Power is saved.

In the rare occasions—perhaps 5 per cent. of the cases—when the stop is so long as to allow the motor and gear to come to rest, it is simply on a par at the next start with the other method, for the motor is able to start the loom from rest if called upon to do so.

The success of this application is only another exemplification of the saying that successful engineering lies along the path of utilizing Nature's forces as they are manifested, rather in overcoming them, be it ever so masterfully done. Thus, after only two years of active development a distinctively American form of drive is being produced and perfected. Under strong competition the next few months will see mainly the refinement of the application through the design of special apparatus for the work and the esablishmen of definite and recognized standards dictating what methods best apply to each case as it arises.

INDUCTION MOTOR CHARACTERISTICS AND THEIR RELATION TO ITS APPLICATION

By J. W. Rogers

THE successful application of a system of electric driving for industrial purposes requires a knowledge of the operating characteristics of the motor and also those of the driven machine, so that the motor installed may be in every way suitable for the work it has to perform. Before it is possible to determine the most suitable type of motor for any particular service, it is necessary to take a complete series of characteristic curves, and from these data relating to (1) variation of speed and torque, (2) slip, (3) rating, (4) efficiency and power factor, may be obtained. These characteristics have a direct bearing on the performance of a motor, and they may be considered as follows:

Speed-torque characteristic — The most important characteristic of the induction motor is that which shows the relation between the torque and the speed at which it is developed. When load is put on a motor its speed falls until the induced E.M.F.'s in the secondary are sufficient to develop the torque required by that particular load. As the load is increased the torque increases and the speed decreases until the stalling point is reached, when both torque and speed fall off rapidly until the motor stops. If the increase in torque was proportional to the decrease in speed, the resultant speed-torque curve would be a straight line, as represented by T^1 in Fig. 1. In practice, however, a speed-torque curve assumes the form of T^2 for the following reasons:

Firstly—As the counter electromotive force of the primary winding decreases as its I.R. drop increases, the magnetic field will be diminished, so that the speed must fall off more rapidly than the torque increases to generate the induced currents required in the secondary.

Secondly—The induced electromotive forces in the secondary are opposed by a counter electromotive force, consisting of a series of local electromotive forces set up by the stray magnetic fields, due to the primary and secondary currents, which necessitates a further drop in speed for any particular value of torque.

If the speed of an induction motor remained constant, the torque developed would be proportional to the watts output and the losses in the secondary, but, as already stated, the torque increases to a greater extent owing to the fact that the speed drops as the load increases.

The torque developed is directly proportional to the watts input to the secondary and varies as the square of the voltage impressed on the primary winding, owing to the fact that an increase in the voltage causes a decrease in the leakage. As a motor requires a rotor of fairly high resistance to enable it to exert a large torque at starting, it will be of interest to consider the effect of varying values of resistance in the secondary circuit, reference being made to the curves in Fig. 2, which represent the torque at different speeds corresponding to different values of controller resistance in the secondary circuit of a Westinghouse variable-speed motor. From these curves it will be seen that as the secondary resistance increases, the slip is increased proportionately if the same value of torque is required;

also, a low secondary resistance gives the smallest drop in speed for a given increase in the torque developed, but gives a low starting torque at the expense of a large starting current, so that this condition is, therefore, more suitable for running purposes. When the "slip" is large, the starting torque is greatly increased for a small increase in the starting current, but falls off rapidly as the speed approaches its synchronous value; the torque developed at any given 'slip' being proportional to the square of the impressed voltage. It will, therefore, be seen that increasing the secondary resistance within certain limits will cause an increase in the "slip" and starting torque, and diminish the starting current; also, the torque is directly proportional to the secondary resistance at starting, but is "inversely" proportional when the motor is running on load.

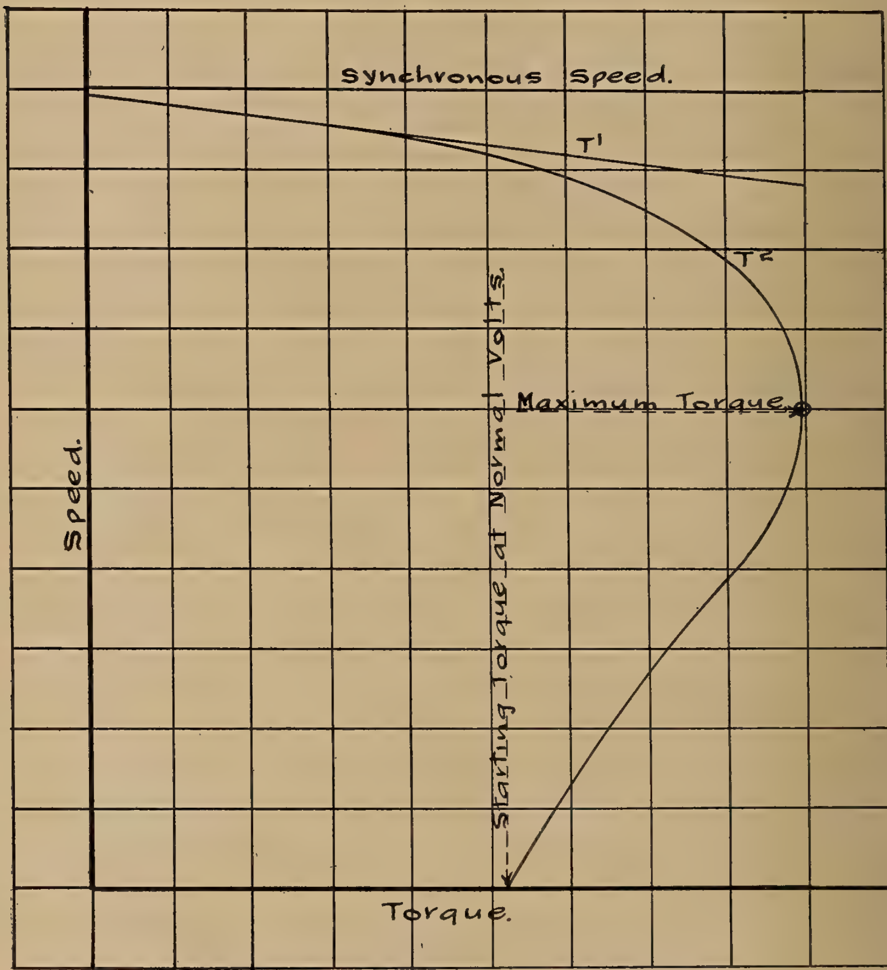


FIG. 1.—SPEED-TORQUE CURVE OF AN INDUCTION MOTOR

Slip—As is well known, the synchronous speed of an induction motor is given by the number of alternations of the supply circuit, divided by the number of poles, and the difference between this speed and the actual speed of the motor at any

particular load represents the "slip," which is generally expressed as a percentage of the synchronous speed. The slip increases with the load, so that the torque developed is increased sufficiently to take charge of that particular load. The slip is directly proportional to the resistance of the secondary winding; it also represents the I^2R loss in this winding, because the slip at any particular load is just sufficient to generate the induced electromotive forces necessary to drive the secondary current through the ohmic resistance of the windings. For these reasons the "slip" expressed as a percentage of the synchronous speed is equal to the I^2R loss in the secondary expressed as a percentage of the watts input to this winding.

The slip varies inversely as the square of the impressed voltage; that is to say, if the voltage is doubled the "slip" is reduced to one-quarter of its former value if the torque is the same in each case.

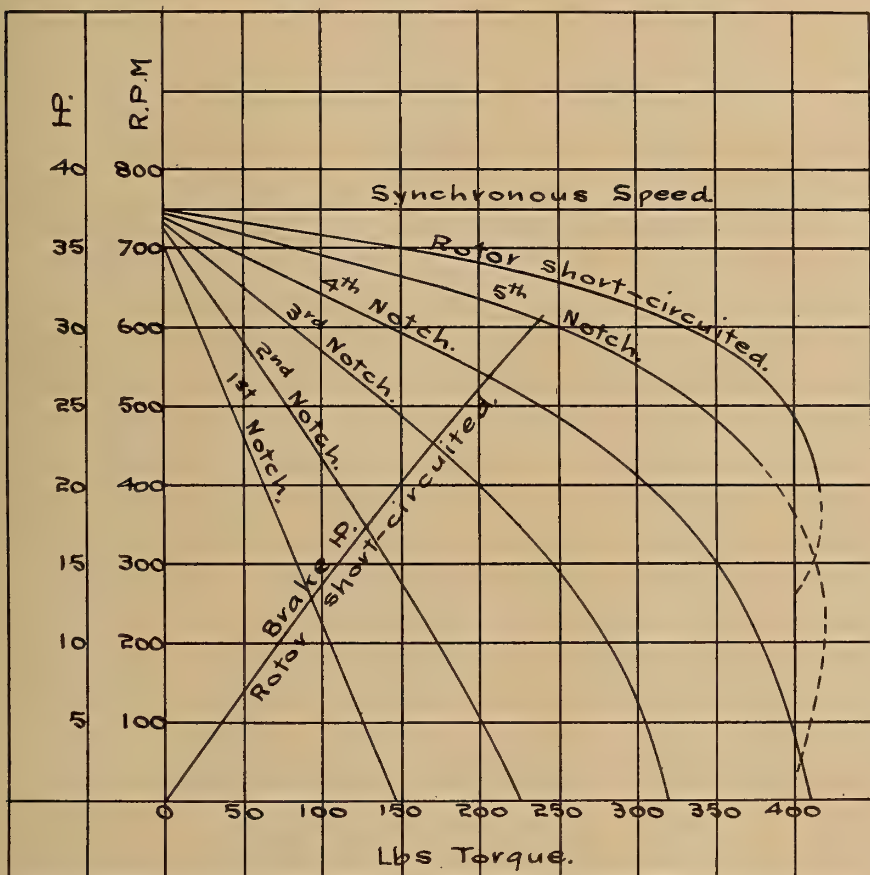


FIG. 2.—SPEED-TORQUE CURVES CORRESPONDING TO DIFFERENT VALUES OF CONTROLLER RESISTANCE IN THE SECONDARY CIRCUIT. WESTINGHOUSE VARIABLE SPEED MOTOR

Rating—Generally speaking, a motor is rated so that it will carry its normal load continuously with a definite rise in temperature, which varies slightly with different makers but is usually about 50 degrees centigrade. The "rating" of a motor should, however, depend upon its type and also on the conditions under

which it has to operate. When a motor has to work under continuous running conditions, the above is the only satisfactory method of rating it; but in the case of haulage or crane work, where the maximum power is only required occasionally and for short periods, the rating of a motor used for this class of work should be governed by what is known as the "intermittency factor." With this method of rating, although a motor may be considerably overloaded for short periods, at frequent intervals it would be standing and so have every chance to cool off. When the rating of a variable speed motor is to be governed by the intermittency factor, the fact that it has sometimes to deliver its maximum power at its lowest speed should not be overlooked. Under these operating conditions the effect of the "intermittency factor" on the rating of such a motor should not be so great as in the case of a constant speed machine.

The "intermittency factor" affects the heating limit on which depends the rating of a motor, and, as a machine can stand a larger overload when running at its highest speed, owing to improved ventilation, too much allowance should not be made for intermittent-working when a motor is called upon to deliver heavy overloads at low speeds, from the point of view of overheating.

Efficiency—The ratio of the actual to the synchronous speed of an induction motor is sometimes taken as a measure of its efficiency which is inversely proportional to the resistance of the secondary winding, consequently it is inversely proportional to the slip. An induction motor generally has its maximum efficiency at about three-quarter load, which indicates the most suitable distribution of the losses for obtaining a motor capable of good, all-round performance. There is a large variation in the efficiency at different speeds for any given value of torque, and as an increased torque is accompanied by increased secondary losses, it is impossible to have large torques and high efficiencies. The fact that a motor has a small efficiency at low speeds is not, however, of great importance, unless it is running at reduced speeds for the greater portion of the time it is working.

Power factor—As regards the power factor of induction motors, this is rather low at light loads but increases rapidly with the load; also, when a machine is working at a voltage much below its normal value its power factor will be diminished. On the other hand, an increase in the voltage above its normal value will also cause a decrease in the power factor, due to an increased iron loss, on which it depends. As is well known, the iron loss is made up of magnetizing and leakage components, and as the magnetizing component has a constant value at all loads and the value of the leakage component varies with the load, the effect of the former on the power factor will be greater at light loads, consequently a motor having a large magnetizing and a small leakage current will have a low power factor at light loads. On the other hand, a small magnetizing and a large leakage current will result in a high power factor at light loads, which will fall off rapidly as the load increases. When a motor is required to develop a high maximum torque, as this requires a large magnetizing current, the power factor at light loads will be low. Hence, in cases where the magnetizing component is small compared with the leakage component, although the power factor at light loads will be high, the maximum torque developed will be low. We have so far considered the various characteristics common to all induction motors which have a direct bearing on their application to industrial purposes, but before dealing with the selection of the most suitable tvpe of motor for any particular service, it will be neces-

sary to make a comparison of the characteristics of the various types, and for this purpose induction motors may be divided into two distinct classes, viz.: (1) Constant speed machines; (2) variable speed machines. These may again be sub-constant or variable speed service.

Constant speed motors—This type of motor has the smallest slip and also good speed regulation, running at almost constant speed from no load to fairly heavy overloads. The rotor is usually of the squirrel-cage

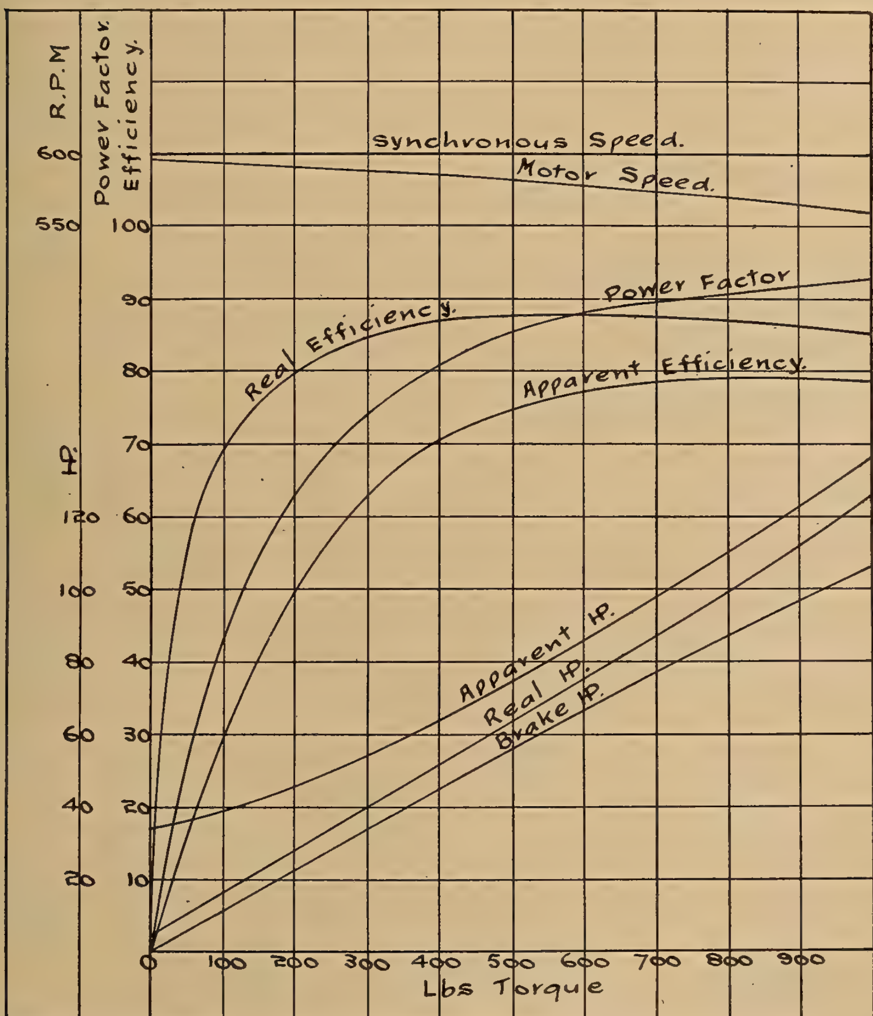


FIG. 3.—CHARACTERISTICS OF A 75-HORSEPOWER THREE-PHASE WESTINGHOUSE INDUCTION MOTOR

divided into two types, depending on the nature of their secondary windings, which may have either a (1) squirrel cage or permanently short-circuited rotor, or (2) a phase-wound rotor connected to slip rings, each of these types being suitable for either type when the capacity of the motor does not require a large starting current and frequent starting is not necessary. As the "slip" is very small, this type has the highest efficiency and best speed regulation. The characteristics of this type are repre-

sented by the curves in Fig. 3, which show the performance of a 75-horsepower, three-phase, Westinghouse induction motor, from which it will be seen that the full load values of the "slip efficiency" and power factor are 4 per cent., 87.5 per cent and 89.5 per cent., respectively, the power factor increasing with heavy overloads on the motor. The full load torque is 680 pounds, and the torque exerted at normal voltage (200 volts), with the rotor locked, was found to be 2,225 pounds, so that the starting torque of this motor is 2225 ÷ 680, or 3.27 times the value of its full load torque.

The starting torque is much less than the maximum torque the motor will develop before stalling or pulling out. It is impossible to obtain a large starting torque with small starting current from this type of motor, as this requires a large slip, but the starting conditions may be improved at the expense of efficiency by substituting end rings made from a material having a higher resistance and smaller section. In the case of large motors of this latter type the starting current is decreased by applying a low voltage at starting by means of an auto-transformer, the torque developed being proportional to the square of the applied voltage.

A reference to the curves shows that the power factor and efficiency are fairly high at all loads; the former having a high value even at light loads.

Variable speed motors—In the case of machines having squirrel-cage rotors, and which are designed for variable speed work, the speed variation is obtained by voltage control, and the speed-torque and current-torque curves obtained at different voltages from a 12-horsepower motor and shown in Fig. 4 serve as an interesting example of this method of speed control. This machine has a rotor of high resistance of such value as to enable the motor to develop its maximum torque at starting, and as a consequence of the high rotor resistance its slip will be higher and its efficiency lower than that of the first type. A great disadvantage of a machine having a high resistance rotor is the fact that energy is continuously being wasted in that part, and as the heat generated passes through the motor, it is liable to raise its temperature considerably.

Phase-wound rotors—The employment of a motor having a wound rotor in conjunction with a variable resistance in the rotor circuit gives the advantage of a high resistance rotor at starting and a low resistance rotor when running on load, which is a high starting torque with low starting current. The speed torque curves obtained from a machine of this type for various values of external resistance in its rotor circuit are shown in Fig. 5, from which it will be seen that the speed remains fairly constant at all loads when the secondary is short-circuited; the motor will also operate at a high efficiency and power factor. A reference to these curves also shows that for any particular value of torque developed by the motor, the power factor and primary current input will remain constant at all speeds at which that torque is developed; that is to say, the power factor and power taken by the motor depend upon the torque developed and are quite independent of the speed. As the controller resistance is cut out, the speed for any particular torque increases, and when the motor is working on load with a resistance in the rotor circuit, the horsepower output will vary directly as the speed. It is, however, not advisable to run such a motor intended for constant speed work on load, with a resistance in its rotor circuit, as it interferes with the speed regulation. The efficiency would be decreased owing to the energy wasted in the rotor circuits, and also the fact that the motor would be runnig much below its normal speed; that is to say, it would be working with a large "slip."

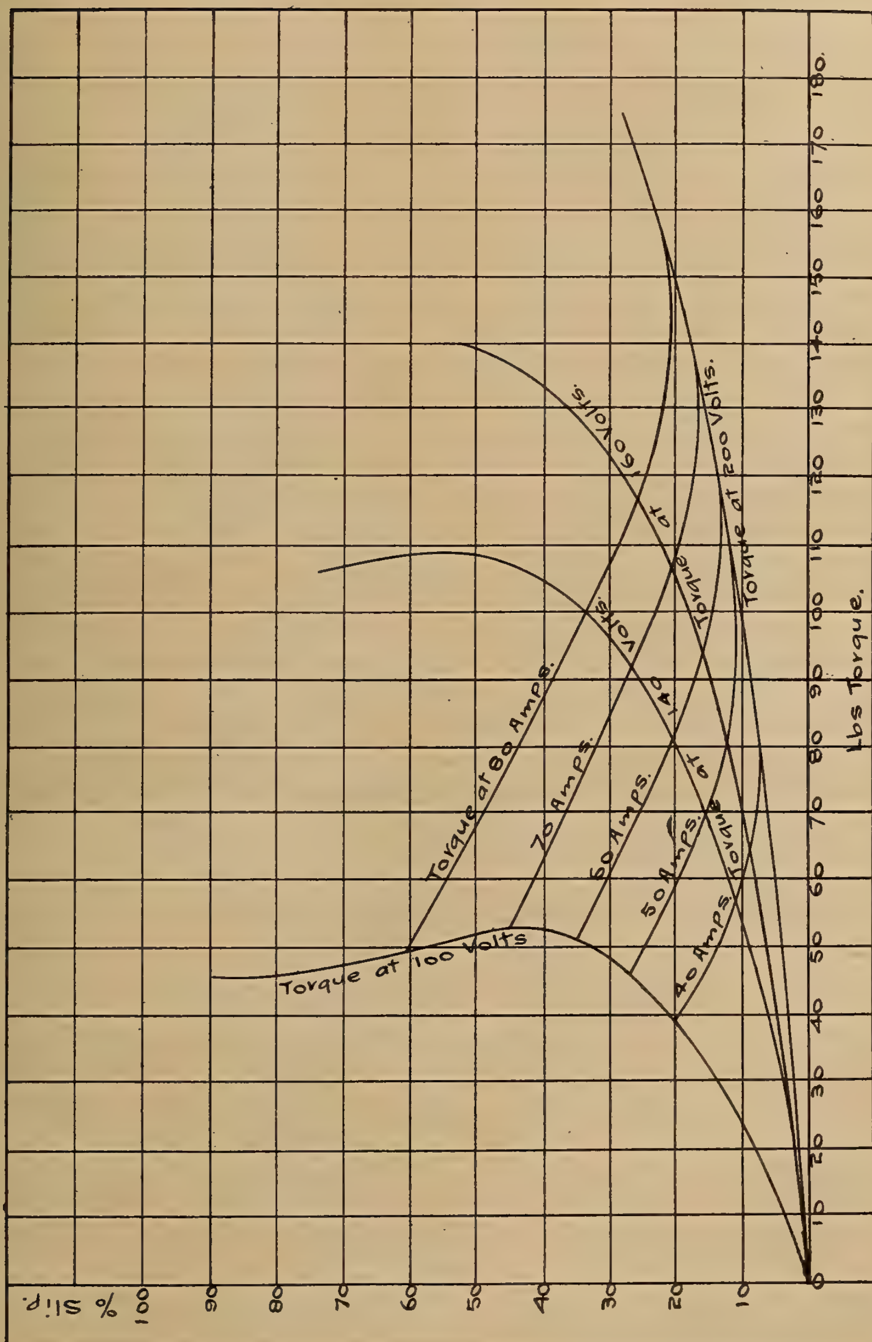


FIG. 4.—SPEED-CURRENT-TORQUE CURVES OF A 12-HORSEPOWER VARIABLE SPEED MOTOR

As regards the wound-rotor type, which is designed for operating at variable speeds, this is similar in some respects to a motor having a wound rotor and designed for constant-speed work. It differs, however, in having a certain amount of quently a low efficiency and power factor. The amount of resistance left in the rotor circuit would depend upon the speed required, and it is possible to so proportion it that the motor would develop the full load torque at starting with little

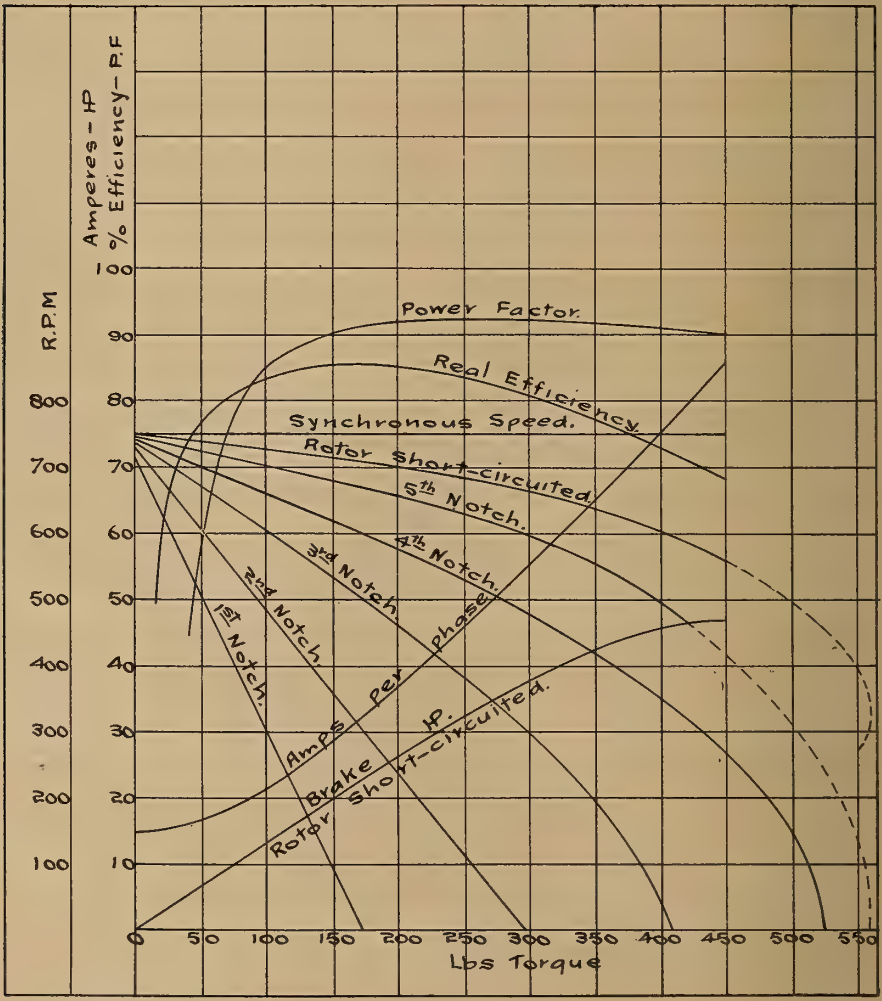


FIG. 5.—SPEED-TORQUE CURVES OF A PHASE-WOUND MOTOR FOR VARIOUS EXTERNAL RESISTANCES IN ITS ROTOR CIRCUIT

external resistance left in the rotor circuit, the speed varying automatically with the torque and horsepower developed by the motor.

As there is a large variation in speed with this type of motor, it has rather a large slip, and consemore than the full load current.

A great advantage of the variable speed motor is its large starting torque, which may be more than four times the value of its full load torque.

Having made a comparison of the

various characteristics of the different types of induction motors, it will now be possible to determine the most suitable type of motor for any particular service when the conditions under which it has to operate are known. There are many purposes for which a system of electric driving would be particularly advantageous, but it will only be possible to mention a few of the typical applications of induction motors which may be used for driving pumps, line shafting, machine-shop tools, fans, blowers and compressors, paper-making and wood-working machinery, fly-wheel, storage and motor generator sets, cranes and elevators, mine haulage, etc., etc.

In all applications of the electric drive to industrial purposes the chief points to be taken into account are: (1) the torque required by the driven machine, and (2) the speed at which that torque is to be developed, so that the most suitable type of motor for any particular service is determined by its speed-torque characteristic, which, generally speaking, has the most important bearing on the application of induction motors. The operating characteristics of the driven machine, so far as the different applications mentioned above are concerned, will now be considered:

Pumps—There are two distinct classes of pumps to which the application of electric driving is particularly advantageous, viz., the ram and the centrifugal type.

A ram pump is generally driven by a constant-speed motor unless it is employed for boiler-feeding purposes, in which case it would be driven by a variable-speed motor, usually of the direct-current type. The load on a motor driving this type of pump increases as the head pumped against is increased, and vice versa.

A centrifugal pump is always driven by a constant-speed motor, the load on which varies inversely as the head; that is to say, decreasing the head pumped against will increase the load on the motor. An increase in the "head" will decrease the load on the motor owing to the fact that a centrifugal pump has no overload capacity. Generally speaking, the requirements of these machines are: (1) Constant power over long periods, with good speed regulation; (2) infrequent starting with low-starting torque, both of these characteristics belonging to the squirrel-cage constant-speed motor.

Line shafting—The conditions under which a motor has to operate when driving long lengths of "shafting" are somewhat similar to those described above in connection with pumps, so that the application of the squirrel-cage constant-speed type of motor would be very successful if loose pulleys were employed, in which case a large starting torque would be unnecessary. In some cases, however, it might be advisable to employ a slip-ring motor.

Machine-shop tools—Although line shafting is sometimes employed for driving machine tools, the following remarks apply to cases where the "individual drive" is in use. The conditions, sometimes abnormal, under which the different classes of machine tools operate, are so varied that a thorough knowledge of the operating characteristics of the driven machine is absolutely necessary to obtain anything like a satisfactory system of electric driving. Machine tools may be divided into two distinct classes. The first class require a reciprocating motion, such as "planing," shaping and slotting machines; the second class requires a direct-rotary motion, such as boring mills, lathes, drilling and milling machines. Some machine tools operate under conditions which require a wide variation in "output" and "speed," and this is particularly the case with cutting tools, and when the application of the electric drive to such tools is under consideration, it is necessary to take into account the character of the work to be machined, density of the

materials used, the depth and breadth of the cut, and also the shape of the cutting tool.

Taking into account the fact that a wide variation in output and speed is required in nearly all classes of machine-tool work, it will generally be found that a variable-speed motor offers great advantages which have a far-reaching effect in bringing about rapid and economical production.

Ventilating fans, blowers and compressors—The load on a fan motor varies directly with the speed, and, although such a motor cannot be said to exert a large starting torque, as this expression is generally understood, it is called upon to exert its full-load torque the instant it reaches its normal speed. The starting conditions of a fan motor are, therefore, severe, and they can only be satisfied by installing a motor of larger capacity than that actually required under normal running conditions; the most suitable type of machine for this class of work being a constant-speed slip-ring motor, although a squirrel-cage motor is suitable for driving small fans.

The load on a motor driving a blower is proportional to the amount of air delivered, and decreases as the pressure against which the blower is working is increased. Blowers are always driven by squirrel-cage constant-speed motors.

The load on a compression motor is proportional to the quantity and pressure of the air delivered, and as constant power over long periods with good starting torque is required, these machines are generally driven by a constant speed "slip-ring" motor.

Paper-making and wood-working machinery—Although the "calendars," used in connection with paper-making require to be operated over a wide range in speed, they are usually driven by constant-speed squirrel-cage motors, the different speeds being obtained by mechanical speed-changing devices. The pulp-grinding and beating machinery requires a large starting torque, but runs at constant speed when running under normal conditions, so that the application of a constant-speed slip-ring motor would prove satisfactory.

Generally speaking, all wood-working machinery, with the exception of planing machines, may be driven successfully by constant-speed squirrel-cage motors having a good starting torque. In the case of planing machines, however, the starting torque required is so high that it is advisable to use a slip-ring motor for driving these machines.

Cotton mills—The machinery used in a textile factory may be arranged for either "group" or individual driving, but in each case a constant-speed squirrel-cage motor will be found suitable for this class of work.

Fly-wheel storage and motor generator sets—The use of the fly-wheel storage system in connection with motor generator sets for supplying power to rolling mills in steel works is one of the typical applications for which a variable-speed slip-ring motor is particularly suitable. As is well known, there is a large fluctuation in the demand for power in heavy reversing roll service where it is possible to have heavy peak loads one instant and the plant running "light" the next; but the difficulty of dealing with such rapidly fluctuating loads has been satisfactorily solved by employing fly-wheel motor generator sets, which consist of a heavy fly-wheel connected between the motor and generator by a reversible, flexible coupling. When the demand for power exceeds the average, the speed of the motor generator drops slightly, which allows the fly-wheel to give up part of its stored energy and thus decrease the amount of power taken from the mains to supply the peak loads. As a drop in speed is absolutely necessary to allow the fly-wheel to give out its stored energy, a motor designed for constant speed

and having good regulation and small slip would not be suitable for this class of work, the characteristics of which are satisfied by a "variable-speed" slip-ring motor having a secondary winding of fairly high resistance. The application of fly-wheel storage is also found in different classes of machine-tool work, such as in punching and shearing machines. For reasons already stated, this class of work requires a motor having a high "slip," and, as the power required is not large, a variable-speed squirrel-cage motor would be found suitable for driving such tools.

Cranes and elevators — Although the period of working is short, these machines require a large starting torque at frequent intervals, and also a large variation in torque over a wide speed range; a variable-speed slip-ring motor would, therefore, be found most suitable for this class of work.

Mine haulage—The characteristics of a motor suitable for "haulage" work in mines may be considered as follows: Under some conditions the motor speed is required to be fairly constant, but when there is a large variation in the load, caused by different gradients on the road, the operation of the haulage plant is more satisfactory when the speed of the driving motor varies automatically with the change in the load. Although constant-speed slip-ring motors are sometimes used for haulage work, a variable-speed motor of the same type would, generally speaking, be found more suitable for such work. Another application of induction motors which may be mentioned is the starting of synchronous machinery, which requires a heavy starting torque and also a variable speed. A motor having a squirrel-cage rotor and designed for operating at a variable speed, would be the most suitable type for this service.

Before concluding these notes it may mentioned that constant-speed motors are used in cases where good speed regulation and a fairly constant output is required over long periods, and large starting torques with frequent starting are not necessary.

As regards the variable-speed motor, this should be used when frequent starting and a large starting torque are required, and where the variations in torque and speed are abnormal. The question of the most suitable type of rotor to employ is decided by the size of the motor and its effect on the generating plant when started. Generally speaking, the squirrel-cage type of rotor is employed when the capacity of the motor is small and the starting conditions have little or no effect on the voltage regulation of the supply circuit. But when the capacity of the motor is large and it is required to work at different speeds, and starting conditions are severe, a phase-wound rotor should be used.

In conclusion, the writer's thanks are due to the British Westinghouse Company for their kindness in supplying data and curves illustrating this article.

THE NEW BRITISH DESTROYERS

ADMIRALTY METHODS

By a Staff Correspondent

THE successful design and construction of torpedo craft for the British fleet depend less upon the initiative and experience of the Admiralty than upon the much wider experience and expert workmanship of the firms which devote themselves in particular to the building of these types of ships, not only for the British Navy, but for the fleets of other Powers. In these circumstances it is not surprising that recent Admiralty practice has occasioned considerable bitterness of feeling amongst those who have laid themselves out to meet the requirements of the naval authorities and have given them the full advantage of their unique experience as designers and constructors of this class of man-of-war.

The building of a destroyer is a special trade based upon scientific data and carried out with a delicacy and accuracy of workmanship which is not to be found, because it is not required, in larger vessels. A well-designed and carefully constructed destroyer is a work of art. Every detail of the construction is carried out with almost the same delicacy as was exhibited by the jewelers in the old days in Clerkenwell and to-day by the builders of swift-sailing yachts such as compete periodically for the great trophies, with this distinction, that a torpedo vessel is a complicated box of machinery in a beautifully worked hull, the weights being calculated with the greatest nicety. The Admiralty consequently has every reason to nurse this special industry and to take every precaution that it shall not be crippled by unfair competition or capital be discouraged from finding employment owing to niggardly terms in the conditions of the contracts given out from time to time.

The establishments which devote themselves to the construction of such craft are a national asset of no mean importance at a time when the torpedo is looming with increasing menace on the horizon. The day has gone by when the torpedo can be regarded as an unreliable instrument of war of strictly limited use. To-day the British Navy is about to be equipped with a torpedo which will carry a destructive charge of upwards of 200 pounds, and will possess an effective range of over 7,000 yards, which it will be able to cover at an average speed of 31 knots. Such a weapon is bound to influence battle tactics, owing to its range and the accuracy with which it runs. The new torpedo, in association with improved gunnery methods, has already banished the familiar 6-inch gun from the newer battleships and battleship-cruisers.

One of the urgent naval problems of to-day is how to employ the new torpedo to the best advantage. It is realized that it is necessary to build special vessels for its use; it is also realized that, in view of the dangerous character of the service which will devolve upon these craft, it is essential not only that the British fleet should possess the best type of torpedo craft, but that it should have these vessels in sufficient number to provide a margin of safety in view of the inevitable casualties of war.

Very briefly this statement summarizes the dominating factors of the moment in the design and construc-

tion of destroyers for the British fleet. Good design, based upon the widest experience and executed by the best workmanship which long training and careful supervision can secure, are absolutely necessary. Unfortunately there is no indication that these conditions weighed with the Admiralty in giving out the contracts for the sixteen destroyers of the naval programme of 1908-09. These contracts were given out in a hurry, for the reputed reason that it was desirable to find work for the unemployed. Just as though a navy could be suddenly turned on to the production of such delicate craft!

Suddenly, at the instigation of the political leaders, inquiries were sent broadcast to practically all the builders on the Admiralty list inviting them to send in tenders for the new vessels. Firms which had never built a destroyer were included, as well as other firms which had built none since the days of the old 30-knot boats, and the present staffs of which, therefore, possessed little or no knowledge of the delicate work of design and construction involved in building such craft. The tenders received, it is understood, ranged from £95,000 to £125,000; and, generally speaking, the firms who realized most completely by recent experience the labour involved in the output of such craft as the Admiralty demanded were those who submitted the higher offers. Some of the lower tenders are believed to have been actually below the net cost of the ships required. In some cases this was no doubt due to want of knowledge of the expenditure involved in the particular type of ship required by the Admiralty, while in other cases probably the work was undertaken on a non-paying basis merely in order to placate the Admiralty and at the same time keep together staffs during a period of serious depression. It should be added that the accepted proposals in every case were not identical, and it will possibly be found that the boats quoted on lower prices will not be equal in dimensions, power or structural strength to those designed and offered at a higher price by firms acquainted with the requirements and how to obtain them.

All the firms in tendering of course acted in accordance with the practice of what they regarded as sound business principles. It must sometimes happen that some firms, owing to particular circumstances, are compelled to undercut; and from their own point of view and that of their shareholders they are, of course, justified in this course of action.

In this case the complaint is not against the firms who tendered, but against the use which the Admiralty made of the tenders. First of all, certain modifications involving extra expenditure, which is estimated to amount to about £4,000 a boat, were made by the Admiralty, and then the lowest prices were accepted for a considerable proportion of the sixteen vessels—nine, to be exact. The Admiralty afterwards proceeded to barter with the other firms who had tendered. It was claimed that the prices they asked were too high. The Admiralty, therefore, at one and the same time required the price to be reduced while making certain alterations which involved extra expenditure. In the circumstances the prices were cut down. It is not known to what extent reductions were finally made, nor the motives which led these particular firms to agree to this extraordinary procedure. The bare fact is, however, common property that the tenders were greatly reduced. No doubt the firms were actuated by a desire to keep in with the naval authorities, and trusted that, although the orders would represent not only no profit, but probably a loss, they would be followed by others on which the Admiralty would permit them to have a more liberal margin of profit.

Whatever may have been the circumstances in individual cases, the fact is that these reduced tenders

were at last arranged, and then the Admiralty put forward other amendments of design which involved further outlay once more; and not until after considerable negotiations was it conceded that these later variations should be accompanied by a corresponding increase in price. Business men will confidently hope that this system of business by the Admiralty will be abandoned, as not creditable to a government department, or, in fact, to any firm of good standing. If the Admiralty were satisfied with the exceedingly low tenders submitted by some firms their course was to give those firms the orders for all vessels they required. It is entirely contrary to established business principle to communicate the low tenders submitted by some firms to the firms who have asked a higher price and demand that the latter shall reduce their charges to the same level as the former. When tenders are wished to be delivered, all by a certain fixed date, it is to avoid tenders being tampered with, and the orders should be allotted on the merits of price and design, then sent in. This is the custom with firms of the highest standing; the system of bargaining after the tenders are sent in is only to be found among third-class firms. It is a particularly unfair method of procedure in the case of a specialized industry. Those who devote themselves to the construction of destroyers and have laid out large amounts of capital on special plant merit consideration on the part of the naval authorities, in order that they may be encouraged by reasonable prosperity to take every advantage of improved methods of construction, whatever the outlay on new plant may be.

In reference to this endeavour on the part of the Admiralty to bring the prices down of all firms tendering, so as to, as nearly as possible, equal the lowest tenders received, fearing that the higher prices asked leave more than a reasonable profit, the Admiralty have only to consider the absence of dividends of the various firms who have been in the habit of working for them to be assured that the price at which they get their work done is not only exceedingly low, but is utterly unremunerative. On the other hand, it is impossible not to recognize the wisdom of the policy on the part of the Admiralty in distributing orders for torpedo boats and destroyers among the various engineering and shipbuilding firms in Great Britain, as it is of the first importance that in case of war the country should be able to procure vessels of this type with the utmost rapidity, this class of vessel being the only class that could probably be built at the commencement of a war and finished in time to take part in such wars; consequently, we are glad to see that the construction of these vessels is not confined, as formerly, to the two firms of Thornycroft and Yarrow, who, although credit is due to them for what they have done in this direction, certainly could not expect to maintain the monopoly when important national policy requires otherwise. The objection is to the system of bartering, which is in every way objectionable. The new Admiralty system of doing business inevitably will have the effect of diminishing the interest and enthusiasm which engineers and shipbuilders in England would have in developing improvements; and, moreover, when improvements are made by private firms they would be more inclined to offer them to other governments, who adopt better methods of business.

What is this type of boat which is being constructed? The new destroyers differ from anything which has hitherto been seen in the British Navy. They are to have a displacement of from 930 to 1,030 tons, with a speed of 27 knots only; they will mount five 12-pounder guns, and be fitted with two torpedo tubes. They differ in almost every respect from the preceding types of destroyers. The early Tribal destroyers displaced

from 950 to 975 tons, with a speed of 33 knots, carry three 12-pounder guns only, and possess two torpedo tubes. On the other hand, the later Tribal destroyers displace from 1,050 to 1,100 tons, have a speed of 33 knots and carry two 4-inch guns, being fitted with the same number of tubes as the other destroyers.

It will be seen that, on the average, the latest destroyers are somewhat smaller than those of the later Tribal class; but in place of two 4-inch guns they are equipped with five 12-pounders. No reason has been assigned for this change in armament; indeed, the general impression was that the gunnery experts of the Government were so pleased with the 4-inch gun that it was intended to mount it exclusively in future destroyers. It is now apparent that if this intention was ever formed it has now been abandoned, and consequently the new destroyers will carry more guns, but of a lighter type. An explanation may be hazarded. When the *Dreadnought* was designed it was determined to mount the new 12-pounder gun of 18 cwt. in all the capital ships of the navy, and no doubt orders were immediately placed for a large number of these weapons. The Admiralty were soon after convinced that the 12-pounder gun was too small to enable a battleship or battleship-cruiser to defend herself effectively at an adequate range against attack delivered by the later destroyers of foreign navies of increasingly heavy scantlings. The presumption is that these 12-pounder guns, discarded for use in the capital ships of the navy, are to be employed in the new destroyers. No doubt it will be urged that the gun carried by a destroyer is intended only for use against similar craft, and that it will come into action at a comparatively limited range at which the 12-pounder can prove effective. Whatever foundation there may be for this explanation, the main point upon which criticism of the new designs naturally centres is the reduced speed and the fact that the Admiralty have abandoned oil fuel and decided to revert once more to coal.

It is curious that the British naval authorities should have abandoned oil fuel at a moment when in foreign fleets it has been decided that its advantages are so considerable as to make it desirable to abandon coal in these smaller craft. It is probable that there is one simple explanation of the change in Admiralty policy. The British Empire has very limited resources of oil fuel, and at present the supplies of the navy have to be obtained from abroad. These supplies may be cut off in time of war, and, therefore, the Admiralty are compelled to sink considerable capital in reserve stores of fuel. The British Navy already possesses a large number of ships which make large demands for oil fuel. All the later capital ships of the navy carry oil fuel in addition to coal, and for some years past all torpedo craft have been fitted exclusively for the use of liquid fuel. Apparently the Admiralty have decided that, in view of the present limited sources of supply and their liability to interference, it is an act of statesmanship not to commit the navy further in this direction. There is every reason to hope that in the near future additional supplies of oil fuel will be available within the British Empire, and then presumably the Admiralty will revert once more to its use in new ships. No one who has any knowledge of the performances of the oil fuel burning craft of recent construction doubts that this agent possesses very great advantages over coal. It is more easily taken on board, and its use results in a considerable saving of labour.

It is less easy to explain the decision of the Admiralty in respect to the reduction of speed. The speed of the new destroyers is limited to 27 knots, while the displacement is far in excess of the old 30-knot destroyers. Indeed, the growth of displacement in British destroyers is a

very remarkable feature in recent designs; the modern destroyer in a comparatively few years has grown from 250 tons to about 1,000 tons, an increase of 300 per cent. For various reasons (particularly owing to the scare caused by the *Cobra* disaster) the Admiralty have gradually developed a type of destroyer which is large and very strong in its scantling, but which affords a great target at sea; which is costly, and of which, therefore, only a limited number can be built; and which is relatively slower in a seaway than the large battleship-cruisers which are now being constructed for the British and German Navies. In a seaway even a destroyer of 1,000 tons will seriously lose in speed—far more seriously, indeed, than a large battleship-cruiser of about 18,000 to 19,000 tons. In anything but a smooth sea these latest destroyers will be inferior in speed to the new large battleship-cruisers which are being designed for the German Navy, besides having the disadvantage of offering a far larger target than the old 30-knot vessels.

Considering the apparent success of the Tribal class of destroyer, it is difficult to understand why the Admiralty have suddenly decided upon a reduction in speed. The new boats certainly do not appear on paper to be equal value in comparison with the later Tribal destroyers, and, so far, the Admiralty have furnished no explanation of the radical change of policy which these new boats represent. It is common knowledge that the swift destroyers of high speed are comparatively light, but quite sufficient scantlings which were employed by the Japanese under all weather conditions during the war in the Far East gave every satisfaction. The evidence in favour of such comparatively cheap vessels is so conclusive that it was generally anticipated that the Admiralty would revert to this earlier type of destroyer rather than continue the policy of adding to the displacement while at the same time keeping down the speed.

It is a noteworthy fact in this connection that the German Admiralty is not imitating British policy. The most recent destroyers of the German Navy displace only 670 tons, with a speed of 30 knots, and mount two 24-pounders, with three machine guns, besides being fitted with three 18-inch torpedo tubes. The difference of three or four hundred tons between the British and German boats must have been absorbed either in heavier scantlings or in increased fuel supply. In either case it is a point for serious consideration whether the Admiralty are pursuing the wisest policy in adopting this latest design of large, slow-speed boats and casting upon the navy estimates such a heavy expenditure for this particular type of craft.

RECENT EXAMPLES OF CONCRETE CONSTRUCTION

By J. F. Springer

THE WYOMING AVENUE BRIDGE, PHILADELPHIA

THE use of concrete has become so firmly established that there seems little necessity for emphasizing its advantages. The increasing demand for steel, together with the inevitable rise in cost with the consumption of available supplies of raw materials, will render concrete construction still more widely used; while its resistance to fire, to the action of water, and to compressive stresses give it advantages which have had much to do with its rapid development as a structural material. When used in connection with steel reinforcement it becomes capable of resisting tensile and shearing stresses as well; and since the longevity of the metallic reinforcement seems to be well established, it is evident that concrete, either plain or reinforced, is well adapted to many important structures.

Among the successful applications of concrete may be enumerated bridges of various kinds; storage bins for sand, coal, etc.; piers, retaining walls, and the like; tanks for water or oil; piles and other foundation work, and certain classes of buildings. In the following pages some of the more recent examples of these successful applications of concrete will be discussed and illustrated.

BRIDGES

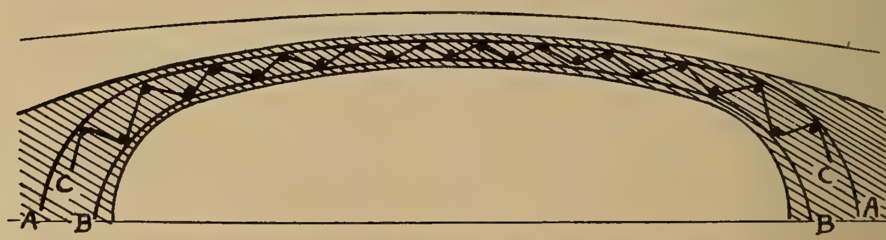
The city of Philadelphia is one of the most extensive users of concrete in the world. It possesses, either completed or in course of construction, fifty-four concrete bridges. These bridges have spans varying from 25 to 233 feet. The Wyoming Avenue Bridge, Philadelphia, is shown both in photograph and in section. This is a graceful arch of 62 feet span. The general method of reinforcement may be understood with the aid of the figure. The rod *AA* is 79 feet long, and consists of two lengths of 42 feet, with a lap of 5 feet at center. *BB* is 69 feet long, and consists likewise of two lengths, with lap at center. Both *AA* and *BB* are heavy rods 1 inch square in section. These arch rods

occur in pairs, at intervals of 1 foot from center to center. A series of transverse rods, ¾ inch square, are wired to the set of arch rods *AA*. Another series, alternating with these, are likewise wired to the arch rods *BB*. The two sets of transverse rods are then bound together by the folds of the longitudinal lattice rods *CC*. These rods *CC* are ¾ inch square, and occur at intervals of 2 feet center to center. They lie half-way between neighbouring arch rods. At the crown of the bridge corresponding arch rods are vertically distant from each other about 9 inches. It will be seen from this example that, in the matter of the reinforcement, dependence is not put upon the adhesion of concrete and steel. In fact, the city government requires that the reinforcement in concrete bridge work shall be so disposed as to effect a mechanical lock with the concrete. The balustrade of this bridge is likewise of reinforced concrete.

A different construction seems to have been revived of late. In this steel reinforcement is omitted and reliance placed upon large stones imbedded in the concrete and set perpendicular to the ring of the arch, these large stones being as numerous as possible. Perhaps this type might be called stone-reinforced concrete. Another bridge over Wyoming Avenue, Philadelphia, affords an example of the use of stone and concrete. In this design the arch is decidedly less flat. The span is, however, 90 feet.

The standard specifications for Philadelphia bridges require that the concrete shall be a 1-3-6 composition. That is, the proportions are, by measurement, one part cement, three parts coarse sand or gravel or stone screenings, and six parts crushed stone.

Cleveland, Ohio, possesses what is, perhaps, the very flattest concrete bridge in the world. This bridge has three hinges of plates and angles. For bearing surfaces plates of cast iron are employed. The hinges were greased before being put in place, to avoid rust. At the joints a half-inch of pure asphalt separates the concrete. The composition of the concrete is a ½-½-5 mixture. Between abutment hinges the span is 86 feet 4½ inches. The rise of the arch above abutment hinges is 5 feet 1½ inches. This flat bridge, of about 13 feet in width, is in Brookside Park.



WYOMING AVENUE BRIDGE, PHILADELPHIA, SHOWING THE REINFORCEMENT

To afford an idea of the cost of reinforced concrete construction, the bridge at Williamsville, Vermont, may be cited. This has a roadway 120 feet in length, is 20 feet 8 inches wide, and has a clear span of 80 feet. The stream is about 50 feet below the roadway. The cost of this bridge was about $6,000. The question of cost depends largely on location, however, so that the price at which reinforced-concrete construction may be done in one part of the country may not be an exact criterion for another section.

In further illustration of cost, the Maumee River Bridge, near the town of Waterville, in Ohio, may be given. This bridge carries a single electric-railway track upon a roadbed 16 feet wide between copings and 45

feet above low water. There are twelve spans, varying from 75 to 90 feet each. The total length of the bridge is 1,200 feet. In constructing it the builders looked far into the future and provided for loads greatly in excess of those of the present moment. The several spans will carry 500 tons each. This bridge of reinforced concrete is thought to be the longest in the world, and was erected under contract for $77,000 by the National Bridge Company, Indianapolis, Ind. It may be of interest to note that the reinforcement called for but 100 tons of steel. The amount of concrete used was about 9,000 cubic yards. The site of this bridge is especially exposed to ice jams. Indeed, a steel structure erected four miles below and having four 140-foot spans was demolished through the action of the ice crowding the piers apart. In the present case the weight of the bridge is so great that but little apprehension seems to be felt.

The Walnut Lane Bridge, in Philadelphia, is one of the most striking examples of concrete construction to be found anywhere in the world. Interest focuses, of course, upon the central arch. This consists of two ribs, each 18 feet wide at the crown and somewhat wider at the skewback. The depth of each rib at the crown is 5½ feet. The clear span is 233 feet, which is a longer span than that of any other concrete arch in America. The roadway is about 150 feet above the surface of the waters of the Wissahickon Creek. The construction is of reinforced concrete. As the ribs were to be identical, it was determined to build and use the centering for one and then move it transversely the 34 feet necessary to bring it into position for the other. The centering was partly wooden and partly steel. The lower, or steel, sec-

MAUMEE RIVER BRIDGE, WATERVILLE, OHIO

tion consisted of a number of trestles supported each by its own concrete pier. When the concrete in one rib had sufficiently matured, the centering was released and the transverse movement effected by means of steel rollers, each 6 inches in diameter. Ten of these corresponded to each pier. They were placed between the lower beams of the steel trestles, and had a rollway of plate steel built into the tops of the piers. The movement was accomplished by means of jacks simultaneously operated at fifteen separate points, and was completed in three days. The load cords. In consequence, the surface of the river rose to within 3 feet of the arch crowns. It is said that no damage was incurred. The question as to whether there was a tendency of the water to back up on the upstream face on account of the obstruction of piers and arches was answered negatively. In explanation, it is asserted that any such tendency was offset by a tendency to acceleration of the current under the arches which a rise would generate. That this is a considerable structure will readily be granted when it is stated that 5,200 cubic yards of con-

WALNUT LANE BRIDGE, PHILADELPHIA, PA. THE MAIN ARCH HAS A CLEAR SPAN OF 233 FEET

amounted to about 1,000 tons. The beauty and grace of the Walnut Lane Bridge are well shown in the illustration. The cement used for the concrete was the Whitehall Portland cement—one of the highest-priced varieties on the market.

The Wayne Street Bridge across the Wabash River at Peru, Indiana, is of reinforced concrete, and has seven spans, ranging from 75 to 100 feet. This beautiful structure, erected by the National Bridge Company four years ago, has been subjected to a very severe ordeal. In January, 1907, the Wabash River was flooded to within about 8 inches of former recrete were used. The amount of steel used in the reinforcement was rather insignificant, amounting to but 50 tons.

One of the finest examples of simple concrete construction is the Connecticut Avenue Bridge over the valley of Rock Creek, Washington, D. C. The arches are circular, seven in number, and five have spans of 150 feet. In length this bridge is 1,341 feet, and in width 52 feet. It required about 60,000 cubic yards of concrete, which was mixed with a Hains concrete mixer. The cost amounts to about $850,000. This contrasts very strongly with the $77,-

WAYNE STREET BRIDGE ACROSS THE WABASH RIVER AT PERU, IND.

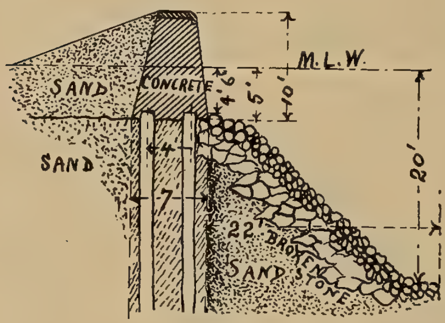
000 for the Maumee River Bridge. The difference is not to be accounted for by the difference in size alone, for the Washington bridge is not eleven times as large as the Maumee structure. There is, however, a very great amount of decorative work necessarily connected with the city bridge, and this, perhaps, accounts for part of the great expenditure.

As to the comparative life of reinforced concrete and all-steel bridges, it is difficult to give data that may be regarded as final. It is quite true that a list of ten steel (or iron) railway bridges has been given of which the average life has been 18.1 years; but this short life can scarcely be regarded as due altogether to the deterioration of the material. A steel bridge often becomes obsolete, not because of inability to carry its old-time loads, but because load conditions themselves have become enormously increased, especially with the railways. After all due allowance is made, it cannot be doubted but that the steel bridge of to-day is not to

CONNECTICUT AVENUE BRIDGE OVER ROCK CREEK VALLEY, WASHINGTON, D. C.

be regarded as a permanent structure. On the other hand, plain concrete has an indefinite life. But it is reinforced concrete whose span of life we wish to know. If it is a considerable fraction of that of plain concrete, then its superiority to steel is evident. If concrete can be relied on to arrest, in a thorough-going way, the usual deterioration of steel, then the triumphant progress of reinforced concrete is well assured.

One of the most striking applications of concrete is in respect to its



NEW SEA WALL, NAVAL ACADEMY, ANNAPOLIS, MD.

use in boat construction. The idea of building a concrete boat is, however, not a new one. Lambot, in 1850, built a boat of this material. About eleven years ago Mr. D. B. Banks built a two-masted schooner, 65 feet in length and 16 feet beam and drawing 14 feet of water, of concrete, reinforced by multitudes of small steel rods. This craft is said to be quite swift in heavy weather, although somewhat slow in light breezes. The *Gretchen* sails in salt water, having been as far north as the vicinity of Hudson's Bay and as far south as Cape Hatteras, if not further. She was once driven on the rocks off Cape Charles, but escaped without damage. About two years ago the Signori Gabellini, of Rome, built a reinforced-concrete barge for salt-water use in the neighbouring waters. This vessel is of 150 tons burden, and is said to have been quite successful.

Concrete has been recognized for centuries as especially adapted to construction exposed to the action of water. Some trouble has been experienced where a wall of concrete was exposed to the freezing action of water which had permeated its surface between tides. But it would seem that this progressive deterioration of the surface is readily preventable by the use of some system of waterproofing. The immunity of concrete to the boring operations of the teredo and the like enemies recommends it for subaqueous construction in Southern marine waters. This marks a great superiority to wood. Wooden piles, for example, are said to have been rendered useless in two years' time on account of the depredations of the little teredo. A further characteristic is of great value. The apparatus necessary in the construction of many kinds of work is quite simple, and can be operated under the direction of a very few highly skilled men. So, indestructibility, moderate first cost, and other items join to render concrete, whether mass or reinforced, a favourite material for such structures as dams, locks, sea-walls, piers, etc.

When the United States Government took up the question of the rebuilding of the Naval Academy at Annapolis, Md., it was found advisable to substitute for the old masonry sea-wall a structure which should be located some distance further seaward, and thus reclaim the intervening tract of land. The site proposed was found to be one of extreme difficulty, mud, for instance, being found 190 feet deep. The first section failed, probably because the full seriousness of the undertaking was not realized. But this failure emphasized the necessity of dealing with the question in the most thorough manner. The general method of construction finally determined upon will be well understood from the diagram, following Mr. Latta in *Concrete Review* (May, 1908). It was determined to build the wall of concrete in mass on wooden piles.

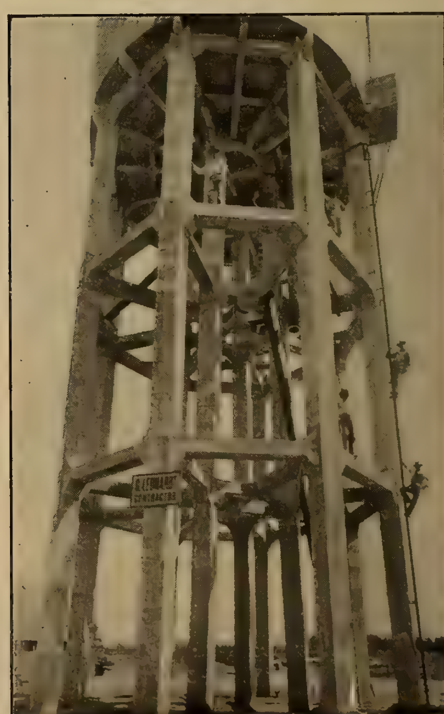
One of the specifications required that there should be a depth of 20 feet of water at no greater distance than 25 feet from the face of the wall. It was determined to place the stone for the rip-rap at an angle of 1½ to 1, although a larger angle was permissible. This condition, combined with the depth of the water required at the distance of 25 feet, fixed the foot of the wall at 5 feet below mean low water. The apparatus employed in connection with At the other end of the same scow was the derrick, used for lowering and raising the forms for the concrete. The mixing scow was provided with bins for the sand and stone, and a kind of hold for the cement. The mixer was placed amidships and a derrick at each end. The one derrick handled the materials to be fed into the mixer, while the other handled the concrete itself. There was a short track on the bottom, on which ran a hand-car for

REINFORCED CONCRETE TANK FLOOR FOR ANAHEIM WATER TOWER

the work was very simple, as will be understood when the items are considered. There was a pile-driver mounted on a float, a scow rigged with a derrick and horizontal circular saw, a concrete mixing scow and a float employed in putting the rip-rap in position. The wooden piles were driven in and then sawed off 4½ feet below mean low water. As this was a variable distance, depending upon the state of the tide, the saw was rigged in pile-driver leads, made adjustable for depth, and arranged upon one end of the scow. the concrete. It will thus be seen that the equipment required for the work was of a very simple character. Salt water was used in mixing the concrete, and had no effect upon the setting. A suitable holding-ground for the piles was provided, where necessary, by a filling of sand. The wall of concrete, 5 feet below and 5 feet above water, 7 feet wide at the base and half that at the top, and 4,900 feet long, was constructed, in addition to the necessary collateral work, for about $350,000, or at the rate of about $71 per linear foot.

REINFORCED CONCRETE WATER TANK, ANAHEIM, CAL.

The adaptability of concrete for novel uses is well illustrated by the case of the water tower at Anaheim, Cal. This structure consists of a large tank supported by a framework. Reinforced concrete is used throughout. It is said to be the first instance of a true water tower built entirely of reinforced concrete. The cylindrical tank is quite a large one, being 38 feet high and 30 feet in diameter. When full of water, the weight of the contents is about 1,500,000 pounds. When moderately full, the lateral pressure at the bottom is about that of an added atmosphere. This pressure—which, of course, diminishes as one ascends—is largely taken care of by the reinforcement of rings imbedded in the circular wall. The wall thickness varies from 5 inches at the base to 3 inches at the top. There are also vertical pieces of twisted steel. The beams supporting the floor in part radiate from the center and in part connect these radii. The reinforcement here consists of bars of twisted steel. The tower proper consists of eight circumferential uprights slightly inclined inwards and of four others close in about the axis. These twelve pillars are mutually braced by two series of horizontal struts dividing the whole of the tower framework into three stories. The uprights are 16 inches square in section. When the weight of the great tank itself is added to its 750 tons of water, it will be seen that the sub-structure is called upon to perform heavy duty at a distance of 60 feet from the



VIEW SHOWING BOTTOM OF TANK AT ANAHEIM, CAL.

ground. The cost was $11,400 for this 180,000-gallon tower. This was very much less than the best estimate for an all-steel structure. Apparently, then, we have here for a less first cost a piece of construction which may reasonably be expected to have a far longer life. Such applications of concrete seem to indicate very clearly that concrete is an extremely adaptable material.

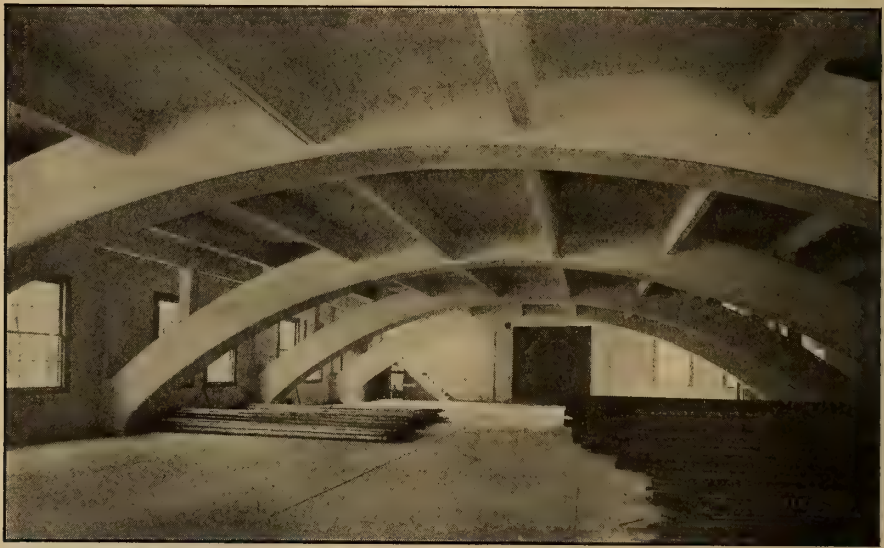
One of the most important applications for concrete is that relating to its use as a foundation support for large buildings. There are two principal methods: Either piles may be driven and the building supported on these or caissons may be sunk and columns of considerable size erected. In the construction of the great Singer Building, on Lower Broadway, New York, the second of these methods was employed. This huge structure rises in its 65-foot square tower portion to the height of forty-one stories (612 feet), and the weight to be supported amounts to about 40,000 tons. Broadway at this point is about 90 feet above bed-rock and only about 15 feet above water, so that for a depth of about 75 feet all excavation was subaqueous. The pneumatic caisson afforded probably the only practicable means of constructing large foundation piers with an absolutely sure footing on bed-rock. The caisson was a stout chamber, open at the bottom and furnished with a sharp edge at its foot. This chamber is where the workmen carry on the excavation by removing material from the surface to which they have access at the open bottom. The caisson is weighted more and more as the work proceeds, and this provides for its descent. If it were not for incoming water, excavation by caisson would be a simple affair. To prevent the ingress of water, the air in the caisson is kept at a pressure superior to that of the water, this pressure amounting to more than two atmospheres for a depth of 75 feet. The sides of the caisson were, however, extended upwards for a number of feet, thus providing moulding boards and coffer-dam. There is an elliptical steel shaft which connects the caisson with the upper part of the excavation, terminating above in an air lock. The shaft is lengthened by adding sections. Each of these is in three parts, and all flanges are upon the interior. As one of the three parts is quite narrow, the sections may readily be collapsed by a man working from within. By the methods followed at the Singer Building the actual construction of the piers was begun at about the same time as the excavation was commenced at the bottom of the working chamber. As described by Mr. Kellogg, a layer of cement mortar (1:2) was first placed on the roof of the caisson. Then a layer of concrete (1:2:4) was placed above. In twelve hours a coffer-dam section full of wet concrete could be placed in position. A second section of coffer-dam would be set in place before the first section was quite filled. While the filling of this second section was in progress the first

BUILDING THE PNEUMATIC CAISSON FOUNDATION FOR THE 41-STORY SINGER BUILDING, NEW YORK

In the center of the foreground is shown a caisson equipped with shaft and air-lock.

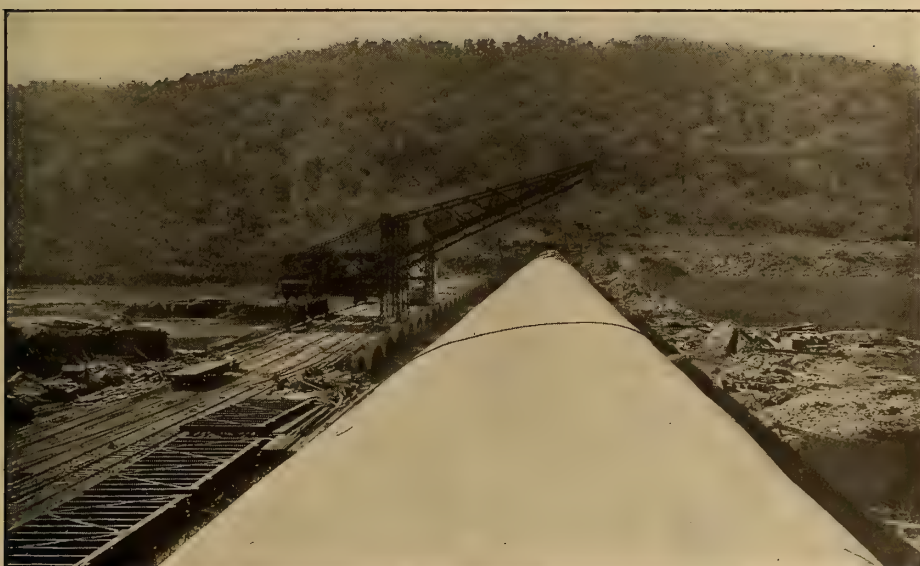
section could be removed and arranged in place above. Two sections of coffer-dam would thus suffice for the construction of a pier. A concrete gang was kept at work, going from caisson to caisson. As the steel shaft was finally to be removed, it was necessary to prevent its adhesion to the concrete. This was accomplished by oiling the surface and then surrounding it with oiled paper. One advantage of this method of construction consists in the fact that the use of iron weights is almost entirely done away with. The growing pier itself supplies an ever-increasing weight. A great advantage of caisson work over pile construction becomes apparent when the excavation is at last completed. It is now possible for a most exhaustive inspection to be made of the character of the footing obtained. However, when a clean and solid surface is secured, the men withdraw and the caisson is filled with concrete. The shaft and air lock are next removed and concrete is placed in the space left by the shaft. The construction of the pier simultaneously with the advance of the excavation is an effective method of economizing time. The procedure partially outlined above is said to be patented as to design and construction of foundation.

At McCall's Ferry, Pa., a great application of concrete is being made. There it is not reinforced concrete, because the conditions do not require reinforcement. Two works are in progress—a great dam 2,500 feet long and a power house 500 feet in length. The dam and the substructure of the power house will consist of an enormous mass of concrete, the cubic yardage amounting to about 300,000. For this concrete about 250,000 barrels of "Giant" Portland cement will be required. In portions of the work large "pudding" stones have been used, as well as the usual constituents of sand and broken stone. The dam stretches from the western shore of the Susquehanna River to a point near the eastern bank. Connection with the shore is secured by the power house, which deviates, however, 42 degrees downstream from the line of the dam proper. It has been estimated that,



GROUND FLOOR OF WAREHOUSE AT JACKSONVILLE, FLA. TURNER CONSTRUCTION COMPANY. CLEAR SPAN OF REINFORCED CONCRETE RIBS, 54 FEET. DEPTH OF RIBS, 3 FEET. THICKNESS, 2½ FEET. RISE, 14 FEET 6 INCHES.

if the dam were a huge monolith 2,500 feet long, the expansion due to a temperature change of 100 degrees F. would amount to 3½ inches. It is scarcely to be conceived that any such change would take place throughout the body of such a mass; at the same time, it is desirable to provide for expansion and contraction. Besides, the river must be cared for during construction. Both requirements have been met in the method of building this dam. With the exception of a long central portion and a foundation stratum, the faces of the sections disclose vertical recesses. The object of these is to supply a bond when the intervals between sections are filled in with concrete. The construction in sections is thought to cover the question of expansion and contraction, and also to have reduced the cost some half-million dollars. An alternative procedure, so far as river-control went, would have been a coffer-dam 2,500 feet long and 40 feet high. The present method dispenses with this costly feature and substitutes a kind of movable coffer-dam. There are



BUILDING THE DAM AT M'CALL'S FERRY, PA. THIS VIEW SHOWS THE "PELICAN" CRANES ON THE TEMPORARY CONCRETE BRIDGE

dam has been constructed in 40-foot lengths. The intervals left have been of the same length. The general appearance of the sections is seen in the photograph. Upon the upstream, or northern, side the face of the dam is vertical, except for a slight rounding at the top. Upon the downstream side, the dam slopes off with a convex face upon its upper surface and a concave one near the bottom of the dam. The reversal of curvature is hidden by the temporary construction bridge seen in front of the dam. It will be observed that the transverse fifteen openings in all, which must, of course, be closed. A "stop log" or gate of steel, 16 feet high and wide enough to extend 2 feet beyond the opening at each side, is hung at the top of the dam. By dropping these gates, closure is effected, although not a perfect one. To effect this, the original plan contemplated (1) the use of an inflated rubber hose arranged to border the gate at the bottom and on the sides upon the face next the dam; and (2) a canvas covering larger than the gate on the upstream face. Of course, the whole

DAM AT M'CALL'S FERRY, PA. THIS VIEW SHOWS HOW THE DAM WAS BUILT UP IN SECTIONS. AT THE EXTREME RIGHT IS THE POWER HOUSE

opening cannot be closed at once by this system; but such closure is not necessary. The curvature at the top of the downstream face is calculated to be more pronounced than the under face of the sheet of water at flood time, so that any tendency to form a vacuum is obviated.

The method of casting the great 40-foot sections is interesting. Steel frames were used, to which actual moulding boards were secured. To put the concrete and "pudding stones" in place in midstream was, of course, a considerable problem in handling. To solve it, a temporary concrete bridge was built along the downstream face of the dam, at a cost of $200,000. Upon this four tracks were laid, straddled by a battery of "pelican cranes." Upon the tracks small railway trains were operated. From these the cranes took the material and swung it into place. The "pelicans" had a track of their own, upon which they traversed the downstream face of the dam. This expense might seem at first blush excessive for temporary work. It is claimed, however, that the cost will be justified through the increased expedition of construction, $15,000 interest being saved for every month the work is advanced.

Current Topics

THE remarkable performances of the Zeppelin dirigible balloon on May 31 and June 1 last demand consideration, notwithstanding the fact that the desired result—a continuous trip from Friedrichshafen to Berlin—was not successfully accomplished.

Regardless of the fact that the proposed trip was not completed, it is yet most worthy of comment that a controlled dirigible balloon has succeeded in remaining in the air for thirty-seven hours, and that it has traversed a distance of more than 800 miles under control.

The full significance of these facts demands consideration. It must be remembered that a distance of only about 300 miles remains to be covered from the furthest north available station and the long-sought Pole, so that a similar trip to that which Count Zeppelin has effected would have availed to carry him across the Pole onward to civilized regions beyond.

Further, it must be realized that the distance from German ports on the North Sea to points on the coast of England ranges from 200 to 300 miles. Thus the German airship might well have traversed this moderate distance and returned twice in a little more than twenty-four hours; and even if no harm were accomplished, the fact remains that the sea has ceased to form the insulation upon which Great Britain formerly depended.

There is no need for alarm in these facts; the nation which has so long maintained supremacy on the seas may well be expected to hold its own in the air. At the same time, it is most essential that no time be lost, and that the well-known facts which control the navigation of the air be applied in England with the same energy and effect as those which have enabled the lead upon the sea to be kept.

There is nothing of importance in the construction of the Zeppelin balloon which is not well known. A reinforced and stiffened series of gas bags, combined with motors of the same type as have already been designed for automobile service—these are surely within the compass of other nations. The aeroplane of the Wright brothers is at the service of any government which is prepared to pay the moderate demands of the inventors; and there seems to be no good reason why the British Government should not immediately place itself in the same, or even a better, position than any enemy which it may have reason to consider.

THERE is a mistaken idea in many quarters that the steam turbine is superior to the reciprocating engine in some principle of action which enables it to get more out of a good vacuum than can be got by a reciprocating engine. There is, of course, no question of principle involved. But there is a question of construction. It is not possible for steam to get out of the cylinder of an engine so readily as out of the turbine, and there is a back pressure on a piston from which the turbine is free. This is simply an outcome of constructive detail. It is impracticable to provide exhaust passages for an engine which shall be sufficiently large to allow the steam to escape sufficiently freely to make use of the best vacua. The turbine opens out full bore to the condenser. It is like an engine whose cylinder stands open-ended to a condenser. Hence the value of the combination of high-pressure engines with low-pressure turbines. There is also the fact that expansion can be carried further in the turbine, so that the sudden drop of pressure is avoided which takes place when the exhaust valve opens. Cylinders to expand steam down to vacuum pressure would be enormous, and would introduce the losses incidental to excessive dimensions. The turbine is free of the worst of these, because there is no temperature variation within it at any one locus so long as the load is steady and the governing is by throttle.

Gust regulation appears to be going out of use. It introduced a fault from which the turbine is by its nature free, and the re-introduction of the fault of variable local temperature always seemed gratuitous. Properly to understand the turbine it is desirable that the student of steam should regard gases, including steam, from the standpoint of the kinetic theory. This theory is a great aid to a clear insight into the behaviour of flowing gases, and it helps indeed to a better comprehension of many of the phenomena of flow, condensing, and even of pressure.

IN the course of an address delivered by the veteran, Professor John E. Sweet, upon the development of the high-speed steam engine, it is interesting to note that he is of opinion that the period of the steam engine has reached the peak in its curve, and that a change is impending. Professor Sweet seems to view the situation with a feeling akin to reluctance, but he is none the less clear in his view of the coming transformation.

In his graphical language, he presents the transition stage in which we are now living:

"It is for us, whose shadows are growing fainter and fainter, to anticipate what is to be the final outcome of our fighting this battle for the high-speed engine. Grass grows up and dies down; trees grow and die; dogs grow and die; and man suffers the same fate. Countries spring up, and flourish, and fade away; and astronomers tell us that the moon is dead, and that there are dead stars. Each and every one of the old slide-valve engines has had its day; a thousand rotary engines have died 'a-borning,' and the glory of the Corliss engine is waning.

"The high-speed and gas engines started together. The gas engine has matured much more slowly, and is about to have its innings. The high-speed engine is changing its coat, and must share the fate of everything else. It has served its purpose, proved its right to existence, been useful, and if it goes down with the Corliss engine it will die in good company."

These thoughtful words of one who has himself been so closely identified with steam-engine development may well be considered by those who have not yet fully grasped the importance of gas-engine progress, and their appreciation of a current phase of engineering evolution is most significant.

LEWIS M. HAUPT

A BIOGRAPHICAL SKETCH

THE subject of our sketch this month is a civil engineer well known as a man devoted to both the practical and theoretical sides of his profession; a teacher, a scientist, a hydrographic engineer, and a writer, active and eminent in all these various sides of his profession.

Lewis Muhlenberg Haupt was born at Gettysburg, Pa., in 1844, and comes by his engineering abilities in large part by inheritance, as he is the son of the late General Herman Haupt, professor of mathematics at the Pennsylvania College at the time of the birth of his son, but afterwards connected with the work of the Pennsylvania Railroad as its superintendent and chief engineer and with other important engineering works. General Haupt undertook, among other things, the construction of the Troy & Greenfield Railroad, and Hoosac Tunnel, the longest in America; and during the Civil War, as chief of the Bureau of Military Railroads, he rendered most excellent service, both in the construction of bridges and roads for the Union armies, and also in the destruction of railroads and communications which might otherwise have been of service to the enemy.

In connection with the work on the Troy & Greenfield Railroad the subject of our sketch began his practical engineering work, being given opportunity on the surveys to see something of the manner in which field work was conducted. At this time he was but fourteen years of age, and his winters were spent at the Greenfield and Cambridge high schools, and later at the Lawrence Scientific School of Harvard University.

In the fall of 1863 he was appointed by President Lincoln to a cadetship at the United States Military Academy at West Point, and four years later he was graduated, and immediately assigned to duty in the United States Corps of Engineers. His first work in the service was with a party then conducting the triangulation of Lake Superior.

In 1869 he was ordered to the fifth military district, in Texas, under the command of General Canby, and with this appointment began his first important connection with the work in which he since has so eminently distinguished himself—the control and regulation of waterways and harbours—his work in Texas including a scheme for the protection of the Fort Brown reservation from the encroachments of the Rio Grande.

In the fall of 1869 he resigned from the government service in order to accept the position of assistant engineer and topographer in charge of surveys of Fairmount Park, in Philadelphia. This work occupied several years, after which he was appointed assistant examiner in the United States Patent Office, in the class of engineering and architecture, which he soon resigned to accept the position of professor of civil engineering in the University of Pennsylvania, which he held until 1892.

Those who had the privilege of study in the university during the period in which the chair of civil engineering was occupied by Professor Haupt can testify to the ability with which this important position was filled. Beloved by his students and esteemed by his associates, he worked faithfully in the development of the department of civil engineering in the University of Pennsylvania, and to-day hundreds of eminent engineers look back to the training which they

received at his hands which enabled them to attain high standing in their chosen profession.

In addition to the absorbing duties of his professorship, Professor Haupt utilized the vacation periods in practical engineering work, thus affording to many of his students unparalleled opportunities for practical experience under his guidance. These engagements included work as engineer in the Fourth Lighthouse District in making hydrographic surveys for the range lights in the Delaware River, as an assistant in the work of the United States Coast and Geodetic Survey, in charge of the geodesy of Pennsylvania, and of various works on the Northern Pacific Railroad.

When the Engineers' Club of Philadelphia was founded, in 1877, Professor Haupt was chosen as its first president, and in its Proceedings may be found many communications from his pen, these mostly relating to the subject which was always near to his thoughts—the development of navigable waterways. This question, to which he has given much attention, includes the broad subject of the utilization of properly directed natural forces to the maintenance of channels and the removal of bars in harbour entrances. Professor Haupt has always consistently maintained that the forces which have created bars and obstructions in harbours are at work continuously, and that, unless their energies are properly directed, they will overcome any temporary efforts which can be interposed by man. His aim, therefore, was to utilize the energy of currents and tides to produce and maintain navigable channels by "reaction," thus dispensing in large measure with the slow and expensive work of dredging, and effecting a large economy in time and money.

These ideas were incorporated in a paper entitled "The Physical Phenomena of Harbour Entrances," which, when presented before the American Philosophical Society in 1887, received its Magellan Premium, the highest award within its power to bestow, and one which had been granted but twice during the preceding forty-five years.

The salient principle involved in Professor Haupt's system is that bars are largely the result of the cumulative action of the flood tide as affected by the general trend of the coast line, and that the improvement of the channels may be automatically secured by properly designed curved breakwaters, so that the concentration of the flow will create and maintain a channel by the natural scour produced by a concave directrix. The correctness of this theory has been amply demonstrated by the results attained at Aransas Pass, Tex., and other places, and the truth of the fundamental principle of thus utilizing the natural forces seems demonstrated.

Professor Haupt has been consulted upon many important public and private enterprises. He was a member of the Nicaragua Canal Commission in 1897-1899; member of the Isthmian Canal Commission, 1899-'02; president of the Colombia-Cauca Arbitration, 1897; chief engineer of survey for ship canal across New Jersey; consulting engineer Lake Erie and Ohio River ship canal, etc. He has been a frequent contributor to the technical press, and his recent articles upon the ports of Liverpool and New York will be remembered by the readers of this magazine. He prepared the special report on railway plant at the Paris Exposition of 1889; also paper on Canals and Their Economic Relation to Better Transportation, 1890; and a Move for Better Roads, 1891.

Professor Haupt is a member of the American Society of Civil Engineers, the American Philosophical Society, the American Association for the Advancement of Science, the National Geographical Society, and Professor of Civil Engineering of the Franklin Institute. Since 1892 he has been practicing his profession in Philadelphia.

WILLIAM H. BRISTOL

President the Bristol Company

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MODERN GOLD PLACER DREDGING

By George B. Massey, 2nd

MUCH has been written about placer dredges. They have been likened to the richly-laden galleons which plied the Spanish Main. "Gold Ships" is a name which appeals to the average mind and smacks of doubloons and pieces of eight. There is a constant effort to associate the placer dredge in the minds of the public with the fascinating atmosphere of the rough, gold-digging days of the "forty-niners."

Nothing could be further removed from fact. In the days of the rush to California the miner started with nothing. If he gained nothing, he was still keeping even. If he made a strike, his assets multiplied rapidly. It was all a gamble. If a stake were not made here, it would be there. Foresight and deliberation—the mental qualifications necessary to success in most other walks of life—were conspicuous by their absence.

The placer miner of to-day is a business man; his tool a great machine, which must be cared for and guided in its work by skilled mechanics. Capital is necessary, there are large fixed charges to be met, the dredge must not be installed unless it has been found, beyond a shadow of doubt, that it will work successfully in that particular spot. The amount of money involved in such an installation makes it necessary that the "grub stake" be made there.

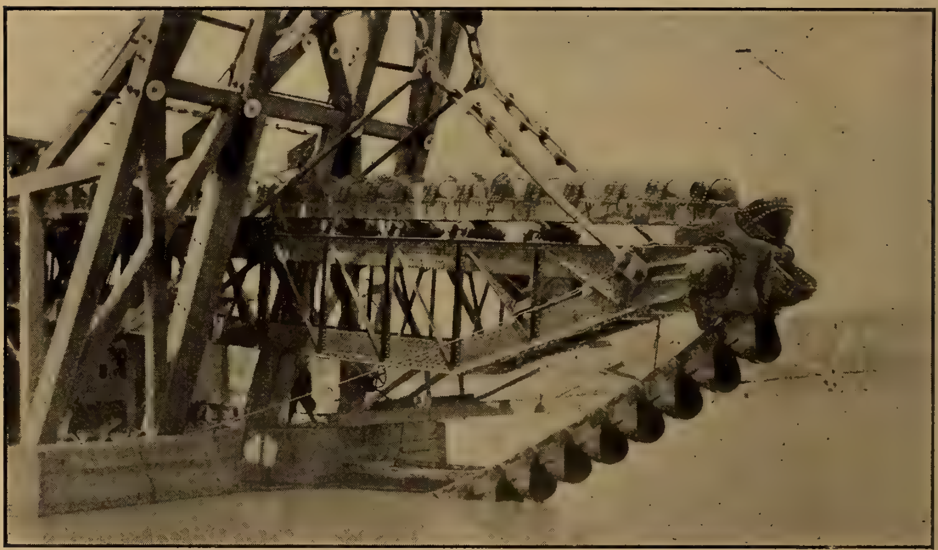
There are stockholders to sit in judgment, and dividends are directly dependent upon mechanical skill and executive ability.

The best dredging ground is invariably located at the point where a stream of water emerges from a gorge or gulch in which the fall has been great enough to cause the stream to scour down between its banks, running always in the same channel. When the stream reaches the mouth of the gorge, the high banks recede on either hand and the water course is free to meander across the slightly sloping flats, the current slackening and the scouring action, therefore, ceasing. As always happens with such streams, it becomes very crooked, dividing into several streams, and, as the years pass, a large area is covered for a time by the running water flowing over successive portions. In the narrow valley, above the mouth, the stream eroded rocks and carried the broken pieces along in the current. Gold, sand, pebbles and boulders all started together.

The boulders stopped first, the heavy gold worked its way down between the boulders, while the lighter gold and the cobbles, pebbles and sand were carried along until the meandering, sluggish current dropped them softly and impartially on the flats.

The dredgeman does not look for nuggets and pockets. They mean large boulders and a hard, uneven bedrock. He prefers the small values evenly distributed and of almost constant quantity, where every yard dug compares favourably with all of the others brought up. It is the ease or difficulty with which it may be reclaimed. This prospecting can best be done by an expert dredgeman who is thoroughly competent to judge of the merits of the proposition as a dredging property. A mining engineer without dredging experience may report on it, but he is apt to overlook some point which an intimate knowledge of the everyday details of dredge operation would recognize as a formidable objection.

With the dredging experts' report, the investor may now approach the dredge builder with sufficient infor-



THE LADDER OF THE DREDGE RAISED IN AIR, SHOWING DETAILS OF THE LADDER

the low-grade property which offers the greatest assurance of success. The statement that a placer runs high in values gives it a setback at once in the eyes of a dredgeman.

The prospecting of a piece of property, to determine the feasibility of dredging it, is done by sinking a shaft, or shafts, to bedrock, to determine the gold distribution, the largest stones, the condition of the stratum known as "bedrock," its depth, etc. This information is now confirmed and added to by drilling holes at regular intervals about the property, until it is known exactly what amount of gold is present and mation to enable the latter to prescribe a dredge which will be perfectly adapted to the conditions present.

Some owners of placer property have installed a small dredge to prospect the ground. Nothing could be more unwise, as the dredge cannot be moved about from point to point on the property and the prospecting cannot be done so thoroughly as with drills.

There are several drills on the market, the most suitable for placer work being the churn drills. These operate by raising a heavy tool or chisel about four feet and dropping

GENERAL VIEW OF A PLACER DREDGE AT OROVILLE. THE BUCYRUS COMPANY, MILWAUKEE

TAILINGS ELEVATOR

it, loosening up the gravel below it and shattering such boulders as may be encountered. A casting of pipe is driven down so as to keep pace with the progress of the drill itself. This pipe prevents the material outside of the drilled area from falling into the hole and thus the material taken out of the pipe by the suction sand pump represents only the area of the outside of the pipe casing. An experienced driller will be able to prognosticate very closely the gold which a dredge will recover. It is next to impossible to drill a property too thoroughly, as the result of the drilling will enable the subsequent movements of the dredge to be directed so as to draw the line at certain values and thereby avoid working too low values.

As the success of a dredging enterprise depends first of all on the ground to be dredged, we will point out in detail the important characteristics.

The points which should be carefully considered about any property are:

1. The stability or instability of the Government of the country.
2. Title to the property.
3. The climate.
4. Accessibility.
5. Depth to bed rock.
6. Kind of bed rock.
7. Presence of trees, sunken logs, or boulders and clay.
8. Water supply.
9. Lay of the land.
10. Nature and quantity of gold.
11. Cost of fuel or electrical power.
12. Length of dredging season.
13. Débris laws.
14. Liability to floods or freshets.
15. Area of dredgeable ground.

BOW VIEW SHOWING CHAIN OF BUCKETS WITH LIPS REINFORCED AT THE CORNERS

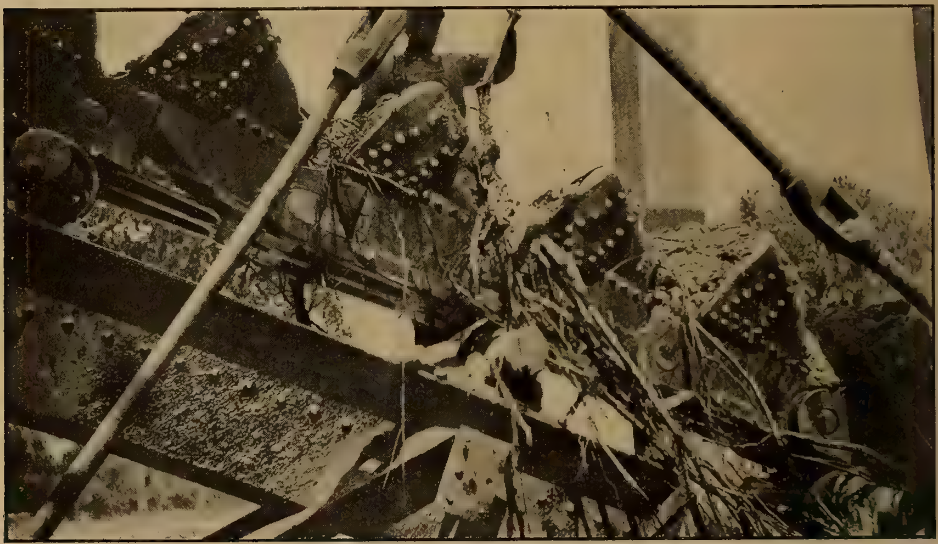
BUCYRUS DREDGE AT WORK ON BONANZA CREEK IN THE KLONDIKE, ALASKA

Taking up each point in detail:

1. Political Condition. — Several promising dredging enterprises have resulted in failure on account of the unsettled political condition of the country in which the operations were to be carried on. It is also much harder to enlist capital—and sufficient capital is absolutely essential. An example of this is the Yaqui country in Sonora, Mexico, which is reputed to contain rich dredging ground, but the failure of the Mexican Government to subdue the Indians precludes dredging enterprises from being carried on.

2. Title to the Property.—This is not such a serious problem in our country, but seems to be a source of endless dispute and worry in South and Central American countries.

3. Climate.—It is, of course, unfortunate that most dredging enterprises have to contend with an adverse climate. In Central and South America, dredging grounds occur in the tropics at such low altitudes that it is difficult if not impossible for the white man to live and work, and it is out of the question to leave the operation of an expensive dredge to the natives, who alone can withstand the disastrous effect of the climate. In the high altitudes at which dredging is being carried on in Colorado, the dredging season is very short, while in the Seward Peninsula, Siberia and the Yukon Territory, not only is the season shorter still, but it is necessary, in the majority of cases, to thaw the ground before it can be dug at all. In the California fields malaria is the only real detriment.



BRANCHES AND ROOTS ARE OBJECTIONABLE

4. Accessibility. — There exist today large placer deposits which will be worked as soon as railroads can penetrate to such proximity to them as to make it possible to convey heavy machinery to the dredging site. It has often been proposed to construct light, small dredges, with each part so much subdivided as to make it possible to transport these parts on mule back. It has been attempted in several instances, but each time has resulted in failure, as the machinery is too light and weak to bring successful results.

5. Depth to Bed Rock.—This is a very important point. The maximum depth which dredges have attained up to now is sixty feet below the water surface. A dredge should

always be constructed to work to the maximum depth found on the property, as the gold is almost invariably present in the largest quantities either just on bed rock or embedded in it.

6. Kind of Bed Rock.—By bed rock is meant the stratum which immediately underlies the placer deposit. It need not necessarily be rock—sometimes a layer of clay. It is quite usual to find that the stratum has crevices and pockets in it, so that, if the dredge were merely capable of scraping over the top surface of it, the gold in the crevices and pockets would be lost. It is absolutely necessary, therefore, to install a dredge which has sufficient strength to allow it to dig up a foot or so of the bed rock and save the gold contained in it. A rock that is too hard to dig will cause an immense loss in the amount of gold saved as compared with the amount of gold present.

7. Presence of Trees, Sunken Logs, or Boulders and Clay.—Trees and sunken logs are encountered in most South American and Central American fields and form very serious obstacles. If standing trees, it is very expensive to cut them down and grub out the stumps in front of the dredge, and if sunken logs, they have to be dug up by the buckets, which is very hard on the machinery, or else it becomes necessary to dig around them and stand the chance of leaving a large amount of gold and of leaving the bed rock not thoroughly cleaned up.

In general, it may be stated that, the coarser the gold and easier to save, the larger are the boulders present. This is because, under the transporting action of the water in the river which has washed down the gravel and gold, the heavier substances find a resting place, while the lighter particles of sand and the finer gold are carried on downstream.

Clay is a serious detriment to success, as it makes it necessary to use a very high pressure of the water for washing so as to disintegrate the material and separate the gold from the other substances. The trouble does not end here, as the clay, in going down over the sluices or gold-saving tables, gathers up gold as a moist snowball gathers up other snow. These lumps of clay are known as "sluice robbers"—a very

INTERIOR VIEW OF REVOLVING SCREEN

effective and descriptive expression.

8. Water Supply.—It is absolutely necessary that a sufficient quantity of water be obtainable. In some localities the bringing of water to the ground has been the principal expense entailed. Of course the water for washing can be used over and over again, but there is always a considerable amount of seepage and evaporation going on which must be replaced.

9. Lay of the Land.—In the first place the dredging ground must all lie below the source of the water supply, that is, all but a few feet, which may be above the water level and which can be caved down by the dredge or washed down with hydraulic monitors. Side hills, of course, are out of the question. The ground must be fairly level or gently sloping, as, if the dredge works up grade, the tailings piles behind are so porous as to allow a large amount of seepage from the dredge pond, and if working down grade, it is necessary to have abnormally long tailings stackers to stack high enough so as to prevent the tailings from encroaching upon the dredge.

10. Nature and Quantity of Gold.—On modern dredges the gold is amalgamated by contact with mercury on the tables. If the gold is rusty and will not amalgamate, it is almost impossible to prevent great loss. The lowest value on any ground being worked successfully today is seven cents per cubic yard, but it is necessary to have the largest dredges and ideal conditions to work such low values at a profit. The

INTERIOR VIEW OF WINCH ROOM

average values in the California grounds are about fifteen cents per cubic yard. The average cost about four and a half to five cents. Some gold, known as flour gold and float gold, will not settle at all on tables of practicable area.

11. Cost of Fuel or Electrical Power.—All of the California dredges operate by electricity, the cost varying from one half a cent per kilowatt hour to a trifle over a cent. Where steam is used, the cost of firemen, woodcutters and men to put the wood on board are necessary, and

if coal is used a large expense is involved in bringing the coal to the dredge. This usually increases the cost per yard of gravel handled by several cents.

12. Length of Dredging Season.—In California and more southern fields work is carried on all the year round. In Colorado about eight months, while in Alaska and the Yukon about one hundred and five to fifteen days, is all that can be counted on. In cold climates it is necessary to heat the dredge by steam, even if electricity is used for power. Where the season is short the general expenses have to be divided by a much reduced yardage, making the cost per yard greater.

13. Débris Laws.—California has débris laws and a débris commission, which limit the disposal of the tailings so as to prevent the silt from interfering with navigable channels and causing inundation of farm land. It is altogether probable that other States will follow suit, although the damage from this source is largely overestimated.

14. Liability to Floods and Freshets.—The danger from this source is usually only a menace where a dredge is working actually in a river bed or in a river bottom which may be overflowed. South American rivers are very liable to overflow their banks without adequate warning, while in California several dredges have been washed away and wrecked in the floods of the winter just past and the one of a few winters ago. Dredges at work on the benches alongside the streams do not have this danger to contend with.

15. Area of Dredging Ground.—It has come to be the rule with dredgemen of experience to allow to each dredge an area to work which will give ten years' work for the dredge. The hulls will last, if properly constructed and carefully handled, about this length of time, and the machinery, if in good condition at the end of that time, may be moved and erected on a new hull at another point on the property. It has so happened, however, that the progress thus far in dredging machinery has made the old machinery obsolete, so that the old machines have been abandoned and new ones installed. This is not so likely to be the case now, if first-class machinery is used, as the improvement is not so rapid—

HOPPER AND MAIN GEARS

everything having been more perfected and standardized. Of course if the machinery were erected on a steel hull the hull would last much longer.

In the consideration of any particular piece of ground as to the probable successful operation by dredges, even if any fourteen of the above conditions are satisfactorily met, the remaining one might entirely wreck the enterprise or seriously

affect its power to earn dividends.

It is not the intention to deter anyone from engaging in placer dredging or from investing in such enterprises, but rather to point the way to success by showing how to avoid the dangers and overcome the obstacles by close consideration of each particular piece of property from all standpoints.

After having ascertained that the ground is a good dredging proposition, it is necessary to next turn attention to the dredge to be installed.

The hull must of course be designed of such size and shape and with such regard to the location of the machinery that it will "trim" or "float" on an even keel. The hull can only be designed after the plans of the machinery have reached such a stage that its location and weight are quite accurately known. Some dredges have been built only to find that the hull was so small that the deck was awash or else that one end was down and the other up, making the slopes of the screens and gold-saving tables entirely wrong. Practically all of the hulls of placer dredges contracted for in the United States have been constructed of timber. This has been entirely because of cheapness as compared with steel. The latter is better on account of longer life and fewer repairs, and the tendency will doubtless be in that direction—it will be some years before it is noticeable.

GOLD-SAVING TABLES IN BUCYRUS PLACER DREDGE

The timber hull is either built in a depressed piece of ground which can afterwards be flooded, or else built where it can be launched into a pond. The framework is set up on cribbing or blocking and entirely fastened together by steel bolts and rods so as to form a stiff, rigid unit. The real strength of the hull is in its framework, and the strains upon it when the dredge is working are so enormous and so varied that a vast

amount of experience is an absolute necessity before a hull can be adequately designed.

After the framework is complete, it is entirely covered with planking, which is put on with spikes, all of the cracks being carefully caulked with oakum and the under-water seams being coated with pitch. The framework for the upper portions of the machinery forms part of the framework of the hull and is erected before the planking is commenced.

The hull is now launched or the water let into the pond so as to float it off of the timber blocking. The machinery is then put on board and secured in place.

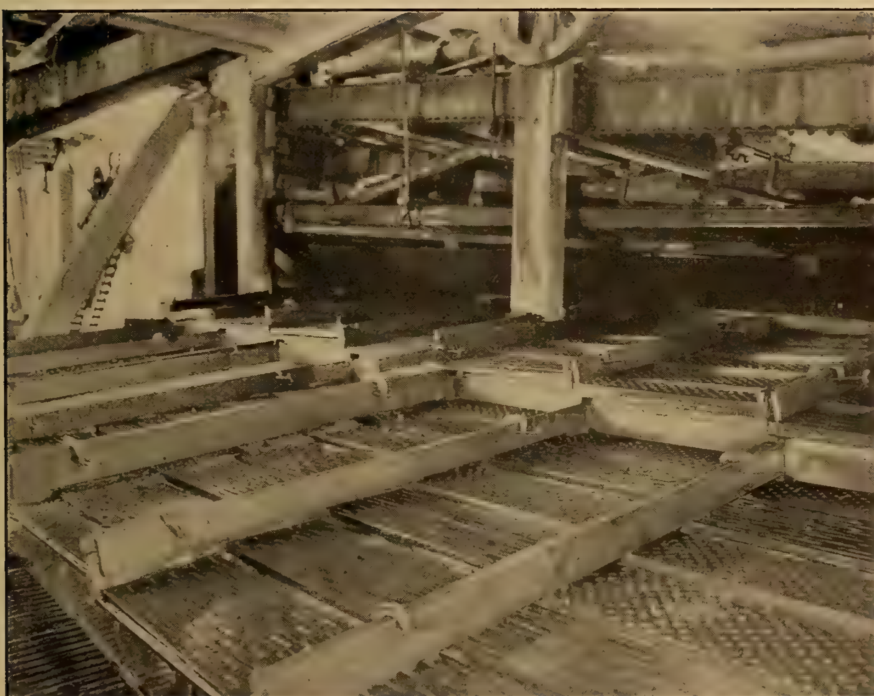
cu. ft. cap. of each bucket.	cu. yds. per month.
3	50,000
5	90,000
7	120,000
9½	170,000
13½	240,000

Most of the dredges operating successfully to-day are of the preceding general sizes and capacities in cubic yards of material handled per month.

Of course there are instances of dredges doing much better than this, but the records thus made were in easy digging. For instance, a thirteen-and-a-half foot dredge has done over 300,000 cubic yards per month.

A first-class dredge will average twenty to twenty-one hours per day. To indicate how the weight of the machinery has increased, a five-foot bucket which was considered heavy six years ago weighed four hundred and fifty pounds with its pin. To-day it would be very easy ground in which a competent dredgeman would think of using a five-foot bucket and pin weighing less than thirteen hundred and fifty pounds—just three times as heavy as the practice of six years ago.

Not only is the improvement shown in weight but also in quality of material. There are special steels



GOLD-SAVING TABLES AND SHAKING SCREENS

being used in bucket bottoms to-day which have an ultimate tensile strength of 125,000 pounds per square inch. Sixty thousand to seventy thousand pounds used to be considered good.

When dredges were undergoing the development stage the buckets would frequently break and the whole line drop into the dredge pond. Sometimes it would tie itself into most awkward knots and hours and days would be lost in fishing it up and repairing it. Now such a happening means that someone in charge of the dredge has shown very poor judgment. The buckets of to-day show a remarkable life. One set of five-foot buckets installed eighteen months ago show a wear on the bottom of the bucket and on the pin of only one quarter of an inch, meaning that the bucket chain should have a life of four years at least. In the case in question the original buckets with which the dredge had started work were still in place, not one having been replaced.

Dredges are now almost without exception what are known as "close-connected," which means that each bucket on the bucket chain is connected directly to two other buckets.

The open-connected bucket chains, with a plain link alternating with a bucket throughout the chain, have been gradually eliminated from the California fields until now only one remains. The reasons for the superiority of the close-connected dredges are that the strains are reduced, as the dredge does not buck and surge so much; then the capacity is sixty per cent. or over greater than the open-connected dredges. It takes no more power to pull a close-connected chain, as the power is practically applied to one bucket at a time.

Revolving or shaking screens are used to separate the small material from the large. The large is carried up at the stern by the tailings stacker, while the small material is carried over the gold-saving tables in a stream of water and discharged at the stern by sluices, the gold remaining behind the riffles on the gold-saving tables.

The dredge has two spuds," as they are called, located at the stern a few feet each side of the center line of the hull. One of these is the digging spud and the other the walking spud. Both slide in ways or guides and may be raised by the winches on the dredge. They fall of their own weight. With the digging spud dropped, it forms a fulcrum about which the dredge may swing from side to side, the front end being pulled, first one way and then the other, by lines running in near the bow and fastened to the shore.

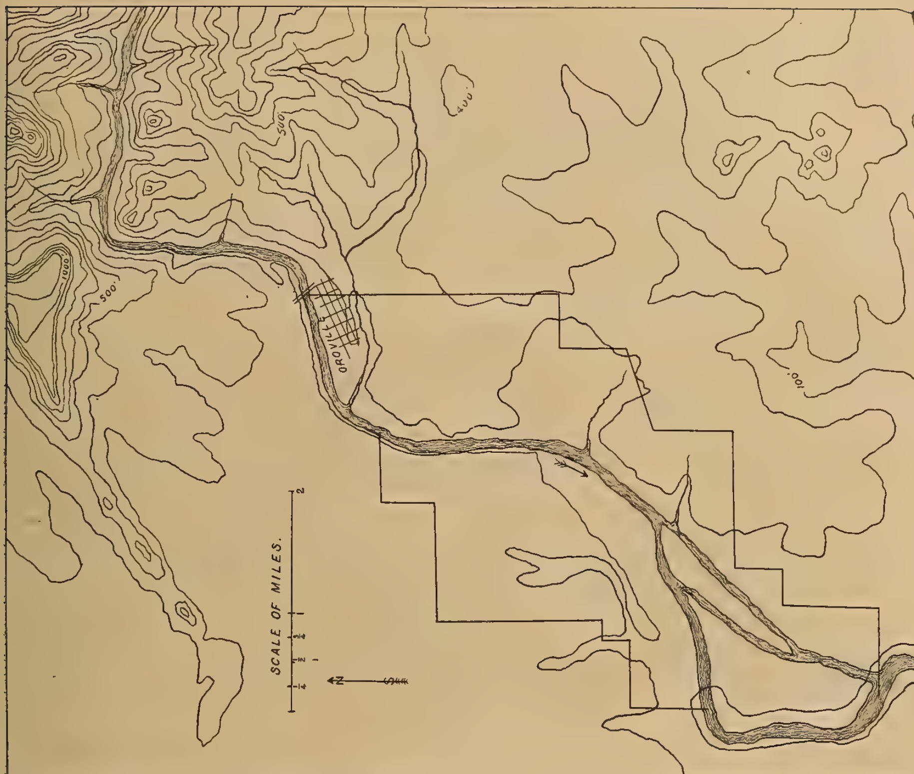
The bucket chain is now lowered, and as the buckets come in contact with the material to be excavated the dredge is pulled sidewise, forcing the corner of the bucket into the bank. After swinging through its arc, the bucket chain is again lowered and pulled back across the cut. This continues until the top few inches of the stratum underlying the gold-bearing gravel has been excavated.

By letting the walking spud drop when the dredge is at the proper angle, the digging spud is raised and the dredge swung to the opposite side of the cut. The digging spud is now lowered and is several feet—five or six—forward of its previous location. In this manner, the machine is moved forward that much. The walking spud is now raised and digging resumed.

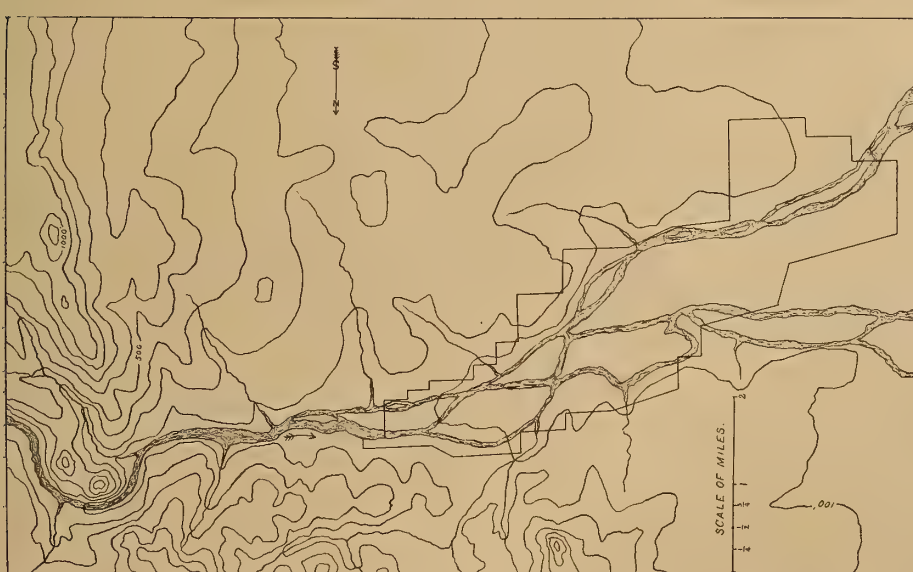
The width of cut is usually about one hundred and twenty feet, although sometimes, owing to the shape of the area being worked, a double cut is taken. This is done by pulling the entire dredge sidewise before moving up.

There is an erroneous idea, which has gained some considerable credence in California, that the operation of the gold dredges ruins large areas of land for agricultural purposes.

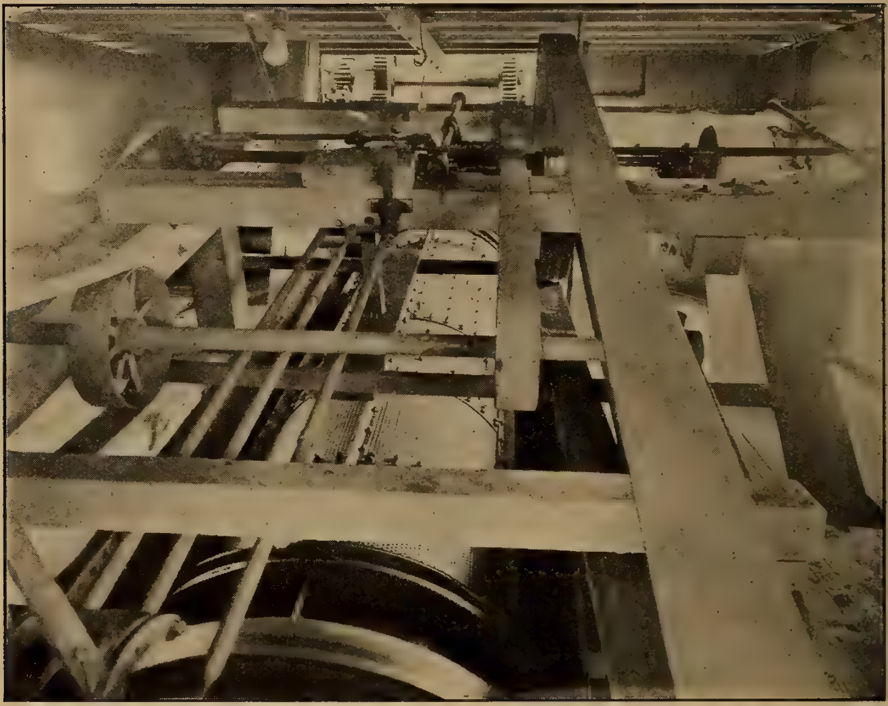
It is, of course, true that the dredges have dug up a good many



DREDGING AREA NEAR OROVILLE, CAL., ON THE FEATHER RIVER



DREDGING AREA NEAR MARYVILLE, CAL., ON THE YUBA RIVER



TOP VIEW OF REVOLVING SCREEN

acres of land which formerly had been used for vineyards and peach, almond and apricot orchards. The ground is rendered temporarily unfit for agriculture, it is true, but experiments have demonstrated the fact that by levelling off the rock piles, it is perfectly feasible to plant eucalyptus trees and orchards by simply putting a little earth about their roots to give them a start. The moisture finds its way up through the loose gravel and the trees grow well.

It is also a fact that the rock piles are being used to furnish material for road-building, rock crushers having been installed.

If we take as an example an acre of ground thirty feet deep, it will contain about forty-eight thousand cubic yards of sand gravel and cobbles. The profit, if the gold runs fifteen cents to the cubic yard, should be ten cents a yard at least. This gives a profit of four thousand eight hundred dollars. If we add to this the profits returned by the crushing of the rock for road-making and then replant the ground with orchids, it will readily be seen that it is one of the finest examples of economical development anywhere to be found.

At Folsom, California, the profit obtained from several dredges is being used to defray the expense of reclaiming sixty thousand acres of land nearby.

The industry has been a marked and entire success in California in the Sacramento Valley, but practically no stock in the companies has been available to the public.

The operations there, however, have shown that ground with very low values can be successfully dredged, and large areas of ground elsewhere will be exploited in the next few years which were not considered dredgeable until recently.

There is no mining which offers surer returns on the money invested, if properly managed, than placer dredging.

SHIPBUILDING OF YESTERDAY AND TO-DAY

By George Leslie

IN no branch of human effort have greater strides been made during the last three decades or so than in ship construction and design. Thirty years ago iron, which had previously supplanted wood as a shipbuilding medium, and itself brought radical changes, was on the eve of being displaced by the subtler material, mild steel, with its greater tenacity, less comparative weight and wider usefulness.

The completeness of the surrender of iron to steel is forcibly brought home by the fact that the iron to be had so plentifully when the demand was great cannot be bought now. Material there is of the name, but take a sample and compare it with a piece broken from a hull discarded after thirty-five or forty years' useful service. Inspection and mechanical testing alike prove the older material to be superior. It is not, of course, that metallurgists are less ingenious than formerly; but that iron, having served its day and proved a stepping-stone to higher things, no longer claims the attention it did, and consequently tends to fall in quality in keeping with its reduced importance as a constructive element.

It is not too much to say that the advance in shipbuilding since the introduction of mild steel has been greatly helped by the possibilities of that material. Particularly has this been so in matters of detail—and ship construction is made up of details. Since every joint in a structure is potentially a point of weakness, and as steel plates can be manufactured longer and wider than iron plates, an early improvement was effected by reducing the number of joints. Then the form of joints was dealt with, overlapped end joints being substituted for those of the less efficient and more expensive butt or flush type. It is only fair to acknowledge that the overlapped end joint, though admitted an improvement in construction, was objected to as unsightly and as increasing the resistance to the motion of the vessel. But by fitting the plates with the exposed ends looking aft, the latter drawback was minimized, and custom has long since reconciled us to the former.

Other modifications of comparatively recent adoption directly traceable to the superior ductile qualities of steel are the joggling of plates at the edge joints, particularly those of the shell; also the scarphing of the end joints for the breadth of the edge laps, thus avoiding the use of packing pieces, saving weight and improving the construction. Then there is the flanging of plates to form right-angled joints and bulkhead stiffness, as against the fitting of angle bars, economical improvements clearly, though opposed by some builders on the ground that the loss of stiffness due to the omission of the rolled bar is not made good by merely deepening the web slightly, as is usually done.

The introduction of structural ballast tanks is to be included in the chronicle of progress, although it is something of an old story now. The first ballast tank was, of course, a rather crude affair. First steps are usually tentative, and this was no exception to the rule. We have no intention, nor is this the place, to describe the schemes proposed and adopted from time to time for the

conveyance of water ballast; but a comparison of the earliest water ballast tank with the latest affords no bad illustration of the skill and ingenuity which have been brought to bear upon ship construction in modern times.

The writer has vivid recollections of the first vessel built with an inner bottom having the frames cut at the bilge which came under his notice. This is a story of twenty-five years ago, and tanks so built were very few. It was the first attempt of the firm concerned. Well, the manager and foremen carefully considered the matter, and concluded that the only way under the circumstances to keep the hull fair was to erect the frames complete from keel to gunwale, fair the body, and, after carefully shoring and ribbanding and taking special precautions to prevent movement at the parts affected, to cut the frames on the stocks. This was done, and the job was, of course, a splendid one; but the cost was considerable. Contrast this with the modern method of construction, in which the framing is done piecemeal and the inner bottom is framed and even plated before the structure above the bilge is started with. Everyone frequenting a shipyard is familiar with the long, skatelike body of the completely framed ballast tank and inner bottom, which, as it lies on the stocks, looks like anything other than a ship.

Important departures in ship evolution have also been due to the demands of commerce and the continual striving for economy forced on owners by the keenness of modern competition. It was quickly seen that doubling the size of a steamer need mean little increase of crew or working expenses, and so large vessels became the order of the day. Again, the demands of owners for improved stowage facilities, and for vessels suitable for special trades, led to the suppression of lower decks, tiers of beams and ranges of pillars—modifications, now that they are accomplished, which seem simple enough, but which called for the exercise of much skill and scientific ability, since the standard of structural strength had to be preserved. All this should be borne in mind when reckoning up the progress of the years.

Turning to design, we find developments no less remarkable. In general appearance sea-craft are much changed—it must be admitted, in some respects not for the better. Cargo steamers, particularly, have degenerated in outward form. They are clumsier, more angular, less graceful, than formerly. One looks in vain in our waterways for the clipper bows, rakish masts and trim sails of the early traders. The changes which culminated in the "tramp" of to-day came gradually. First the masts, already reduced in number, size and importance by the supersession of steam over sail power, were stripped of yards and square sails, and later of trysails, in some steamers not even a staysail being carried. Now, alas for sentiment! masts are frequently fitted without rake; and gawky a ship so fitted looks alongside those of the older style. But a raked mast is a bad derrick post, and efficiency first, appearance last, is the present rule.

Even standing rigging, with its convenient rattlins, beloved of the youthful mariner, is disappearing in favour of the widely-spaced guy ropes, a prosaic iron ladder riveted to the mast, giving access to the masthead. In many vessels, too, forests of derrick posts stand up awkwardly from the deck, making, with derricks and running gear, when seen on the skyline, a most extraordinary show, the ships looking for all the world like floating factories.

But why detail the degeneracy? It is the new cult in shipbuilding, and, whatever we may think, has come to stay. Outward appearance apart, however, change of design has always been in the direction of simplification of parts, perfection of detail and general improvement. Thus the standard of comfort has been

raised. Forecastles are not the pokey holes they once were. The limit of deck space per man is greater, the 'tween decks loftier, and light and ventilation improved. Officers, too, are seldom now accommodated in the bridge 'tween decks, with its close atmosphere and passages smelling of the engine room, but are housed on the upper bridge, in roomy central apartments, airy, dry and convenient to the deck. Railed gangways now span the dangerous wells; bulwarks have been raised and strengthened. The vulnerable machinery openings are protected with substantial casings, and bridge fronts are strong enough to defy the wildest seas.

Moreover, the modern steamer is designed on scientific lines, which could not be said of its early prototype. Thirty years ago there was little science and much rule of thumb practiced in the designing offices of the shipyards. Not unfrequently the model was made to please the eye and the lines plan afterwards drawn from it. No one can defend this practice, although the graceful forms of the clippers of that day were thus evolved.

Before the Daphne disaster few private firms went the length of making stability investigations. What were metacentres and centres of gravity? Vessels had been built since the Ark with little regard to such matters, and could still be built; so the clipper experts reasoned. Then came the Daphne accident and changed all this. Stability became everything. The technical papers were full of it, the scientific societies were full of it; budding naval architects spoke of little else.

In this connection, the writer recalls a little incident which came within his personal knowledge, and shows the spirit of the times. In a certain yard a vessel was about to be launched. The firm was old, and had many launches to its credit; but the general manager was troubled. What if she should upset? Two such Clyde disasters were unthinkable. The chief draughtsman was summoned and the position explained to him. At the time the draughtsman knew nothing of the vessel's condition; but an hour later informed his chief, to that gentleman's great relief, that the vessel was safe. How was it done, since this is no age of miracles? Simply enough. He assumed a position of centre of gravity. One is reminded of the mariner who securely moored his ship to a buoy, then went to sleep, and woke up to find his vessel on the rocks.

Things are different now. Every respectable establishment has its reliable expert. Vessels are designed on paper and their qualities ascertained before a hammer is lifted in the yard towards their construction. The number of calculations made for a single ship is truly astonishing. Estimates of displacement and dead weight, also of strength, stability and trim under service conditions, and countless calculations of a minor character, are the usual routine of an office.

A master stepping on a new ship is not now entirely ignorant of her sea-qualities. Frequently he is supplied with information which, used intelligently at the outset of a voyage, may save him much anxiety.

On the whole, it appears from this brief review that the trend of modern shipbuilding practice is in the right direction, that there is a healthy tendency to change—to try things—which bodes well for the future of the industry. Developments along the line of economical construction may thus be expected, while vessels of new characteristics will crop up from time to time as circumstances demand them. What the ultimate type, even of the cargo boat, will be it is impossible definitely to predict. If the advance of the last quarter century be maintained, however, the probability is she will be of gigantic proportions and of little outward beauty; but safer, more comfortable, and a better investment for money than anything that has gone before.

RECENT DEVELOPMENTS IN LARGE GAS-ENGINE DESIGN

By Percy R. Allen

II.—THE FOUR-CYCLE ENGINE—AMERICAN PRACTICE

The present article is the second of a series treating of the important developments which have taken place in the past few years in the design and construction of the large gas engine. The first paper, which appeared in the July issue, discussed British and Continental practice in the development of the four-cycle engine, the present one continuing this with a review of American practice. In the September issue the series will be closed with an article treating of the extent to which the two-cycle gas engine has been introduced for large sizes.—THE EDITOR.

IN the majority of American designs overhung cranks are used, so that in a tandem engine or twin-tandem engine there will be only two main bearings for the crankshaft, the rotating part of the dynamo or the fly-wheel being placed between these two bearings. Although this arrangement gets over the difficulty of keeping four bearings aligned, it necessitates a very heavy frame to take the stresses between the cylinders and the main bearings; and whether it has any advantage over the plan of supporting the cranks at both sides is, in the writer's opinion, quite a matter for argument.

Several of the American makers have their own ideas as to the best construction of the cylinders, and have their individual arrangements for valve-gearing and governing.

The Allis-Chalmers engine, as built at West Allis, very generally resembles the Nürnberg engine built in Germany, except that the cranks are overhung and the frames and bearings modified to suit this alteration.

A number of these engines up to 3,000 horse-power have been constructed at the West Allis works, and an illustration of the famous installation put down for the Indiana Steel Company, at Gary, Ind., is shown in Fig. 1. It will be seen that there are seventeen of these engines, all in a line in one power house, all the engines being coupled to units of 2,500 kilowatts capacity, making a total of 42,500 kilowatts, all driven by a veritable street of large gas engines, an installation that would have been undreamt of a few years ago.

The general arrangement of the Nürnberg design, as far as the construction of the cylinders and the method of supporting them at each end, has been adhered to by these makers; but they have introduced several modifications in the construction of the bearings, details of valve gear and ignition appliances, and it is understood that these engines are doing excellent service.

The Snow Steam Pump Company, of Buffalo, who for many years past have had a large experience in building gas pumps for compressing natural gas for transmission in pipe lines, some time ago turned their attention to the construction of gas engines and have evolved an engine after their own ideas which possesses a good many very interesting features, and to this firm belongs the distinction of being the first gas-engine builders to put 21,600 horse-power in one power house in only four units. This installation is at the Martin station of the San Mateo Power Company, which is allied to the California Gas & Electric Corporation, a concern operating a very extensive distributing system linking up some important towns on the Pacific Coast. These gas engines have to run in parallel with a water plant 150 miles away, and also the steam plant nearer home. The cylinders of

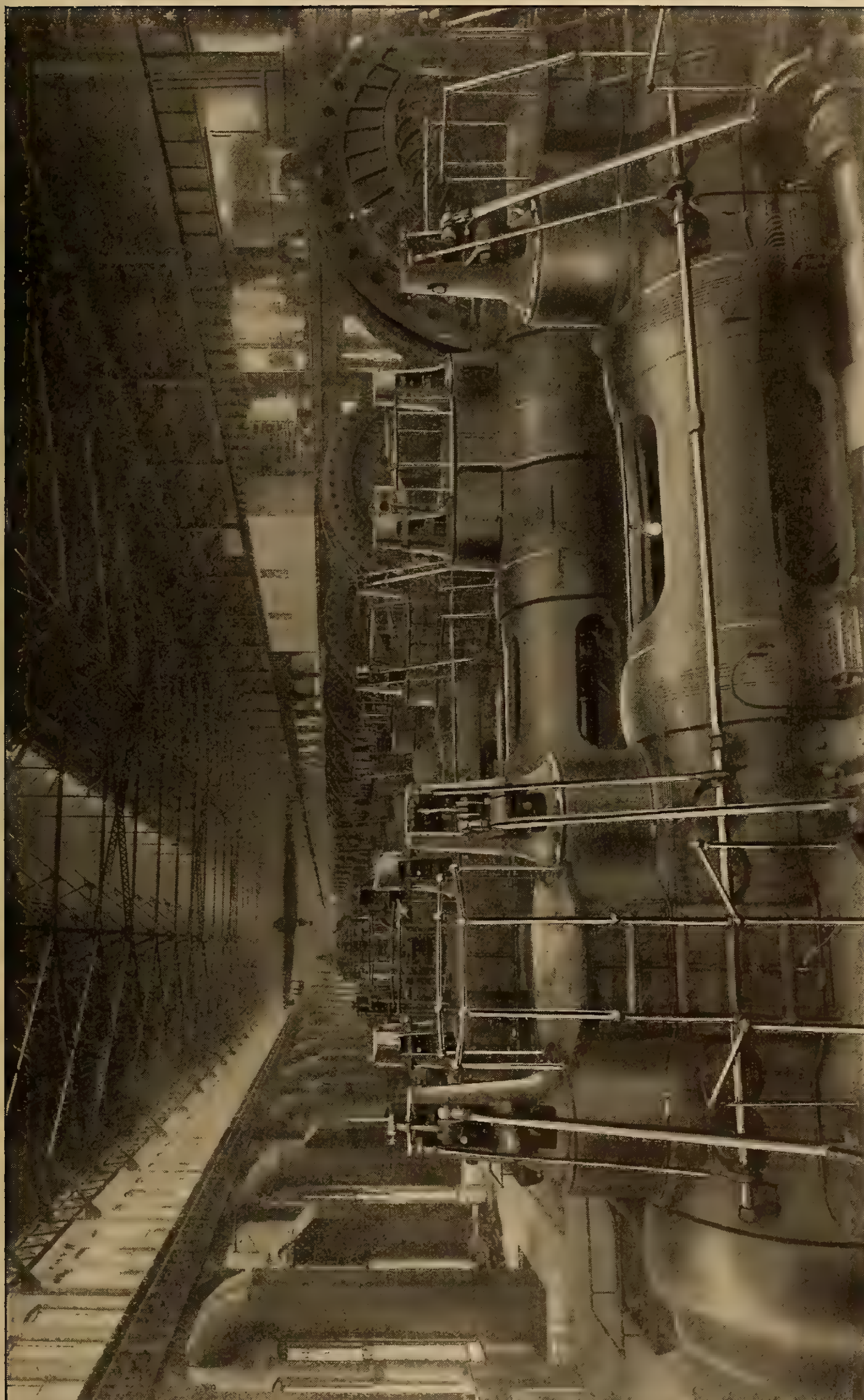


FIG. 1.—SEVENTEEN ALLIS-CHALMERS TWIN TANDEM GAS ENGINES AT THE INDIANA STEEL COMPANY'S PLANT, GARY, IND. THEY ARE DIRECT COUPLED TO ALLIS-CHALMERS GENERATORS, EACH UNIT BEING OF 2,500 KILOWATTS CAPACITY

these engines are 42 inches in diameter by 60 inches stroke, and develop their rated power at from 88 to 90 revolutions per minute, and have even then a considerable capacity for overload. The gas used is made from crude oil by the Lowe process, and, when fixed, results in a kind of water gas having a value of about 600 B. T. U. per cubic foot. Such large engines as these have naturally created a great deal of interest in the gas-engine world; but as they have already been illustrated in the Gas Power Number of CASSIER'S MAGAZINE, another example of this design of engine has been chosen as an illustration here, Fig. 3 showing a twin-tandem engine of 3,000 horse-power built by the same company for the Georgia Railway & Electric Company for their power house at Atlanta. The engine runs on illuminating gas and drives a 20-cycle, alternating-current generator in parallel with water and steam plants at various parts on the railway system. The four cylinders are each 39 inches in diameter by 54 inches stroke, and the engine runs at 90 revolutions per minute. The construction differs in several points from the Nürnberg type, already described. Overhung cranks at right angles to each other are used, and the makers claim to have been the first to follow steam-engine practice in this respect. As the crankshaft is only supported on two bearings inside the cranks, liberal wearing surfaces are provided and careful provision made for adjusting the brasses. The cylinders are cast in two pieces bolted together by circumferential flanges, the joint being midway between the two ends of the cylinder.

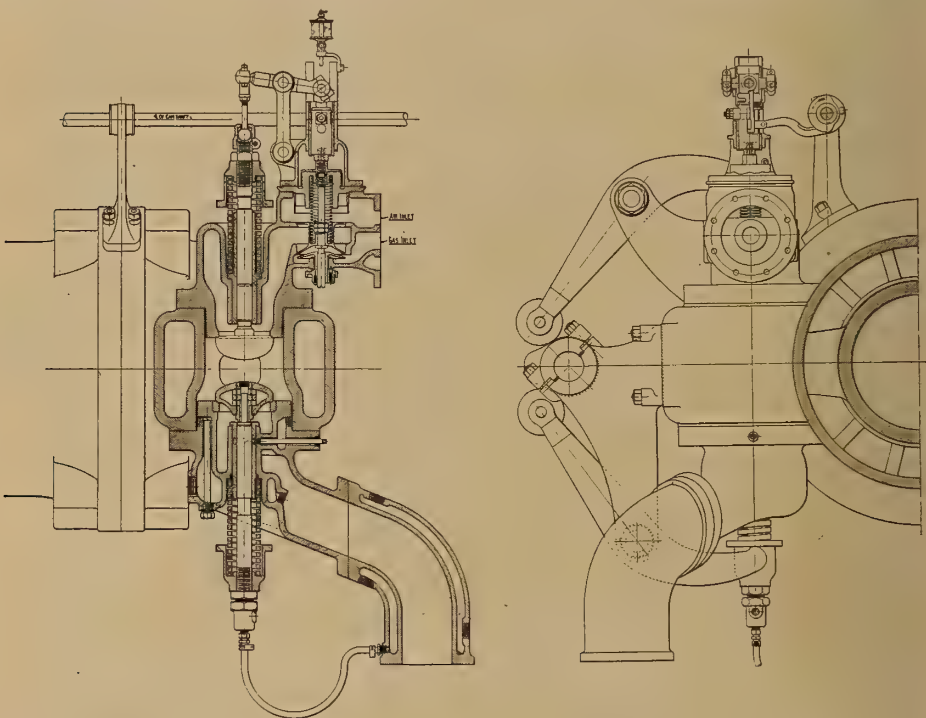


FIG. 2.—GENERAL ARRANGEMENT OF VALVE GEAR OF THE SNOW STEAM PUMP COMPANY'S ENGINE. THE SNOW STEAM PUMP WORKS, BUFFALO, N. Y.

Careful provisions are made for the independent expansion of the inner and outer walls of the cylinder, and the feet carrying the cylinders are supported by means of

tongued and grooved slides formed on a continuous bed-plate extending underneath all the cylinders to the front frame carrying the crankshaft, the actual fore-and-aft stresses between the two cylinders being taken by an intermediate distance piece between the front and back cylinders. The use of a continuous bed-plate prevents the exhaust valves being placed directly under the cylinders, and they are, therefore, located at the sides diametrically under the inlet valves. The Snow Pump Company state that they have from the first adopted the plan of putting the exhaust valves in this position, and give some very excellent reasons for doing it. It certainly renders the exhaust valve very accessible, and it can be readily removed, or, if desired, re-ground in position; and, furthermore, the connections between the cam shaft and the valves can be kept quite short and direct.

The plan of putting the exhaust valves at the side of the cylinder is now adopted by some of the Continental makers—Schuchtermann & Kremer, and Körting, for instance—and the fear that the cylinder would not get properly scavenged out seems in actual working to be unfounded. The arrangement of valves on the Snow pump engines has been modified somewhat since the Atlanta engine was erected, and the latest arrangement for use with producer gas is shown in the section through the inlet valve, exhaust valve and the combined air and gas valve and elevation of the trip mechanism in Fig. 2. The air and gas valves, or what would be termed here the mixing valve, is a plain, double-beat valve, one part closing the air ports and the other closing the gas ports. This mixing valve opens simultaneously with the inlet valve by means of a latch, which automatically engages when the inlet valve is closed, and this latch is tripped sooner or later during the suction stroke by means of cams on a small independent shaft running at the same speed as the main crankshaft and driven from it through a train of bevel gears, one of which floats under the controller of the gov-

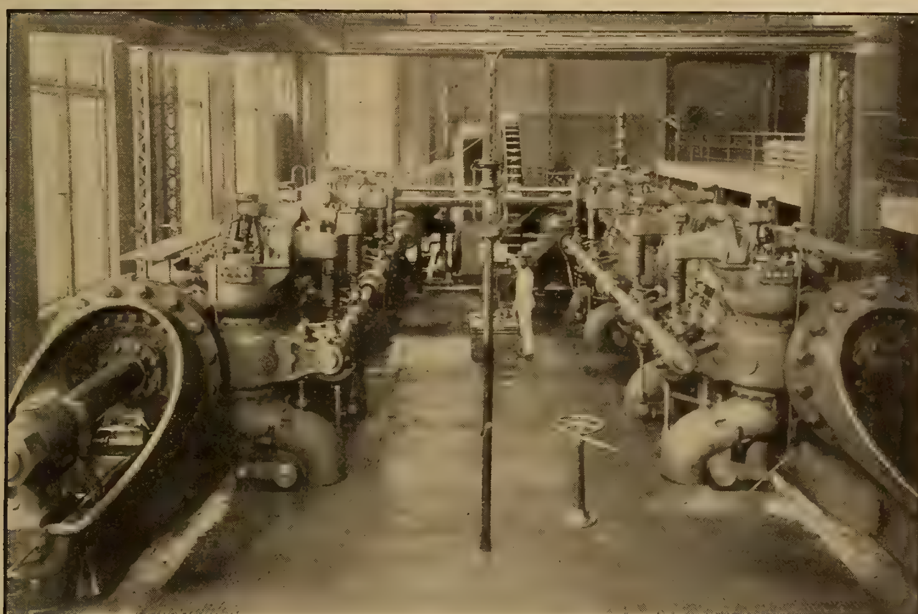


FIG. 3.—3,000 BRAKE HORSE-POWER TWIN TANDEM GAS ENGINE, BY THE SNOW STEAM PUMP COMPANY

ernor, this movement advancing or retarding the movement of the small cam shaft relative to the large one. The conical disc, which will be seen just below the gas inlet to the mixing valve, has a hand-wheel outside the casing, which permits of the proper adjustment of the mixture by hand. When this mixture is properly determined, indicator cards show that complete combustion takes place at all loads. It will be observed that the arrangement just described regulates by quantity governing, the air and gas ports both opening and closing simultaneously. However, the makers use alternative arrangements as circumstances may suggest, and the Californian engines were built with quality governing, and where the engines are applied for such work as driving air or gas compressors the makers state that a single mixing valve in the centre of the cylinder serves to regulate both ends. On the larger engines the rather unusual plan is adopted of making the piston rods solid and continuous from the front crosshead to the slipper at the back of the rear cylinder, and the annular space for the water circulation is obtained by fitting tubes of rather larger diameter over the piston rod, these tubes serving not only to convey the water to the piston, but also, when screwed up at each end, they hold the pistons in proper position. Incidentally, this arrangement does away with any projecting nuts or irregularities on the smooth body of the piston, thus reducing chances of pre-ignition.

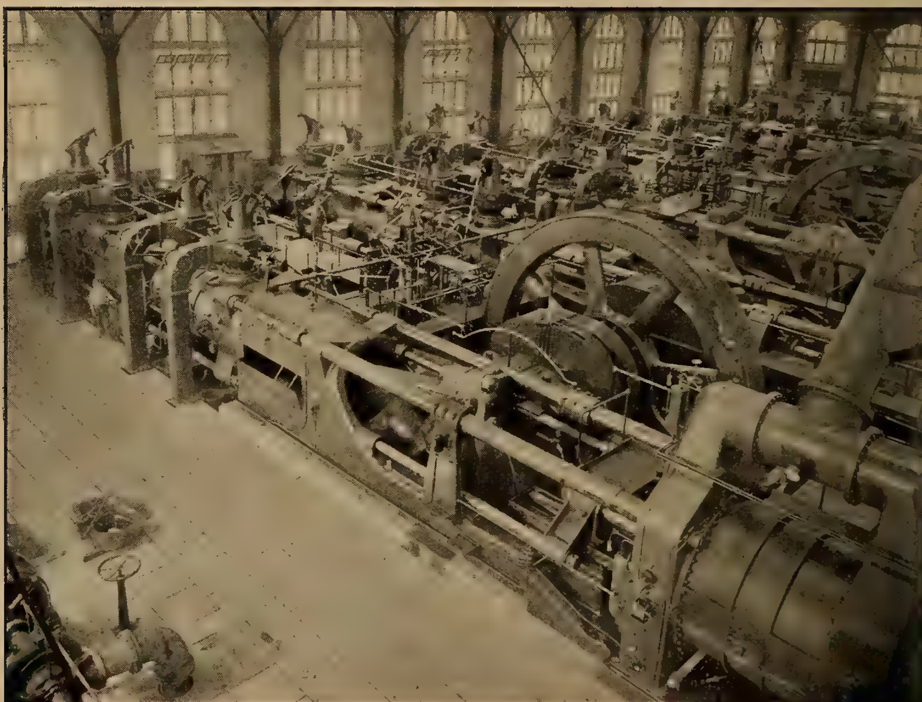


FIG. 4.—FOUR 42-IN. X 80-IN. X 60-IN. TWIN TANDEM, FOUR-CYLINDER GAS BLOWING ENGINES AT THE OHIO WORKS OF THE CARNEGIE STEEL COMPANY (CAPACITY 50,000 CUBIC FEET, 3,000 H.P. EACH) THE WILLIAM TOD COMPANY, YOUNGSTOWN, OHIO

The writer has been favoured by the makers with copy of a complete specification of a 1,000-horse-power engine, but regrets that space does not allow of a detailed reference to the particulars given therein. At the end of November, 1908, the Snow Pump Company had gas engines ag-

gregating 126,780 horse-power running, all in units of more than 500 horse-power, and of this total 53,580 horse-power was furnished by natural gas. Besides these large units, the output of engines smaller than 500 horse-power added up to another 8,000 horse-power.

The William Tod Company, of Youngstown, Ohio, who have for many years been engaged in building large steam engines for iron and steel works, have, during the past two or three years, evolved a design for large four-cycle, horizontal engines which embody some novel features of construction, particularly in the valve-gear and governing arrangements. At first sight the engine seems to resemble generally the Nürnberg design; but, on examination, it will be found that there are radical differences. The makers have adopted the idea of providing for the fore-and-aft stresses between the two tandem cylinders and the main frames carrying the crankshaft bearings, by running four substantial steel rods from one end of the engine to the other. These are screwed at intervals, and large nuts serve to bind the two cylinders between the back and intermediate beds and against the rear of the front bed. The cylinders themselves are not bolted direct to the framing, but are kept in position by means of steel following-rings made in halves, and when these rings are removed the cylinders themselves can be taken out without disturbing anything else, which is a considerable practical convenience.

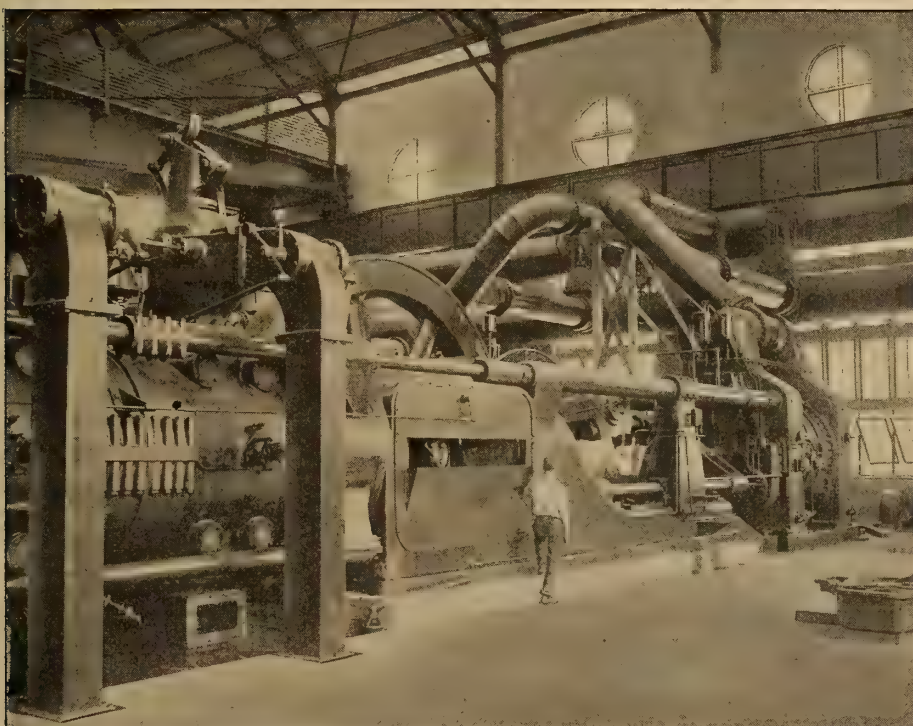


FIG. 5.—VIEW OF THE AIR END OF ONE OF THE ENGINES OPPOSITE. ONE GAS CYLINDER IS ALSO SHOWN. INSTALLATION AT OHIO WORKS OF THE CARNEGIE STEEL COMPANY BY THE WILLIAM TOD COMPANY, YOUNGSTOWN, OHIO

The cylinders are cast in halves bolted together in the centre, and the outer casing has a clear opening extending round the cylinder, the water-

joint being formed here by a removable band. The method of attaching the rear cylinder to the front one by means of stay bolts had already been used by Messrs. Crossleys in England; but in the Tod engine the idea has been very simply and directly carried out, and the arrangement can be clearly seen in the illustrations. Figs 4 and 5 show the large twin-tandem gas engines built by this firm for the Ohio works of the Carnegie Steel Company. The complete installation includes four of these engines, which are said to be the largest blowing engines yet constructed. The blowing cylinders, one of which is well shown at the left-hand side of Fig. 5, are 80 inches in diameter by 60 inches stroke, and are driven by piston rods from the main crosshead. The gas cylinders are 42 inches in diameter by 60 inches stroke, and the engines are described to run between 50 and 75 revolutions per minute, and when developing 3,000 horse-power will blow 50,000 cubic feet per minute. The total length of the engine is 99 feet 6 inches by 40 feet wide. The massive proportions of the engine generally are made very noticeable by comparing the size of the men standing on the platforms. The valve and governing gear is of a somewhat curious design. Quality governing with constant compression is used, the arrangements being such that the rich portion of the mixture is always forced back to the vicinity of the igniters during the compression stroke. A cross section taken through one of the cross sections of the blowing engine is shown in Fig. 6. One eccentric only at each end of the cylinder is used to operate both the inlet, mixing valve, and also the exhaust valve, the eccentric operating through rolling levers, the connection to the inlet valve being made through a kind of wrist plate. The inlet valve, which is of the usual mitre form, works in unison with the combination mitre valve, which admits air through one seat, and gas through the other. The disc valve is placed in the upper part of the valve box, and is partially rotated every stroke by a reciprocating rod driven from the governing gear and connected to the valve by a short link. This rod is driven at the same speed as the engine, and, being actuated by a small crank, has a constant stroke; but its phase of motion is controlled through a train of four epicyclic gears under the action of the governor. At full load the disc valve opens at the beginning of the suction stroke, and gas is at once admitted to form the mixture, while at light loads the opening of the disc valve is delayed, corresponding to the position of the governor, and the gas is only allowed to enter during the latter portion of the suction stroke; in other words, the lighter the load the longer the admission of air only. The disc valve works over a stationary seat, and immediately under this is another disc gas throttle valve controlled by hand through a worm, so that adjustments can be made for varying the quantities of gas, and the end of each cylinder can be adapted independently to give an equal card.

The rotation of the lay-shaft carrying the eccentric is effected by means of eccentrics on crankshaft driving a crank on a parallel shaft, which in its turn drives the lay shaft by right-angle gears. This arrangement is little known in this country, but has been used by the William Tod Company on their fly-wheel pumping engines for a number of years.

It is understood that the Tod Company do not intend to develop this type of engine under sizes of 500 horse-power, and this may, perhaps, be considered a happy omen, as going to show that firms of influence and resources have faith in the future of the large gas engine and are willing to take the risks that are still incidental to its development.

It should be mentioned that the Tod Company are by no means confined to the stratified, constant-com-

pression arrangement just described, and consider that under certain circumstances variable compression is

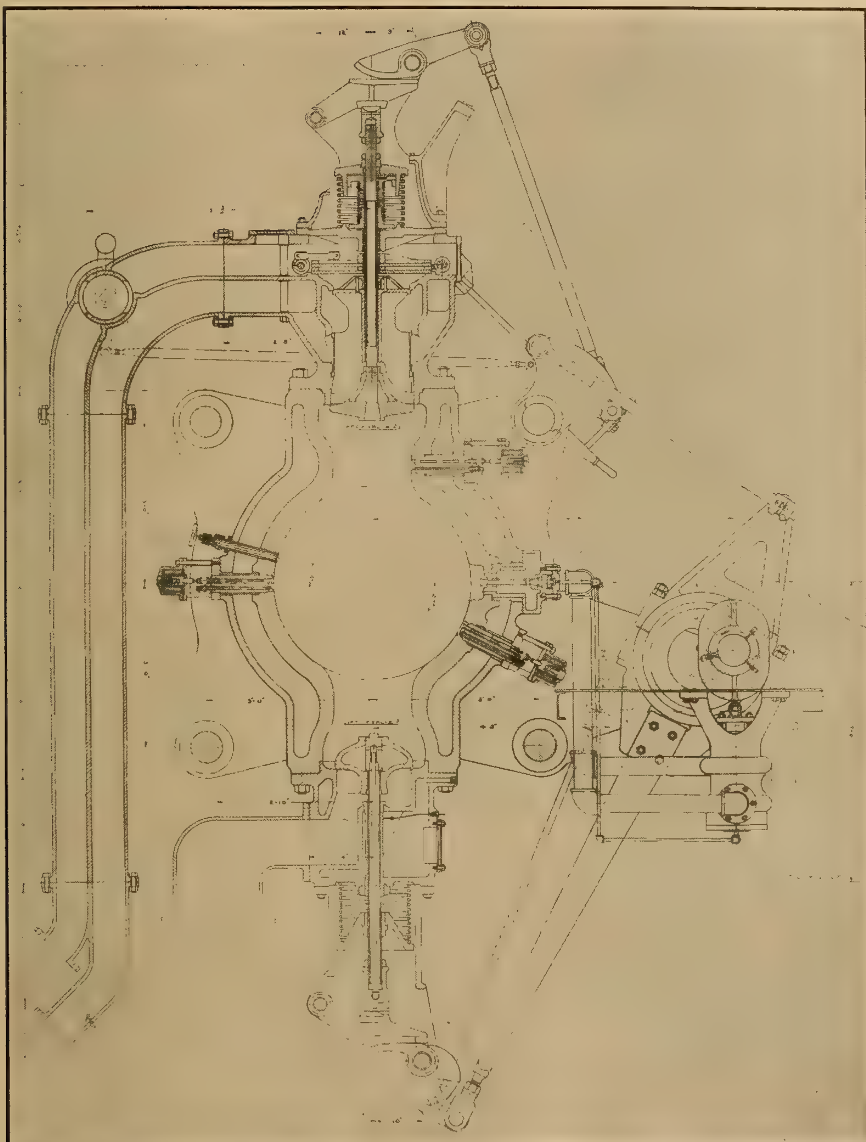


FIG. 6.—SECTION OF VALVE GEAR, 42-IN. X 80-IN. X 60-IN. GAS BLOWING ENGINE. THE WILLIAM TOD COMPANY

quite admissible. Which is actually the best system under given conditions ought to be considered from several points of view, and cannot be discussed here.

It has been proposed by some inventors to vary the compression by altering the clearance in the cylinder ends or by expanding or contracting the body of the piston, but the author is not aware that this idea has yet passed beyond quite the experimental stage.

The Westinghouse Machine Company, in East Pittsburg, recognized

years ago the coming importance of the gas engine, and as long ago as 1896 put upon the market a line of three-cylinder, Otto-cycle, single-acting engines, which soon became very popular on both sides of the Atlantic; and the same type of engine with two sets of cylinders arranged tandem has been recently developed by Mr. Stead at the Trafford Park works of the English company. An illustration of one of these engines of 1,000 horse-power is given in Fig. 10. However, whn the large gas engine for driving blowing engines and large generators for steel works and such heavy duty came to be called for, the American Westinghouse Company offered their own designs of double-acting horizontal engines built either tandem or twin-tandem. The general design of the Nürnberg engine is followed, inasmuch as the cylinders are supported and the stresses transmitted through the front bed, intermediate piece and rear bed carrying the tail-rcd guide; but instead of sinking the exhaust valve boxes below the floor the Westinghouse Company prefer, where circumstances permit, to raise the engines on concrete blocks or brick piers, and thus enable all the exhaust valve gearing to be examined without having to go below. The illustration, Fig. 7, shows an installation of three of these engines intended to be worked with producer gas, but at present being worked on natural gas; and although not very large units being only 500 horse-power, they are interesting as being the first engines in America to work 60-cycle generators in parallel without spring couplings. The engine cylinders are $23\frac{1}{2}$ inches in diameter by 33 inches stroke, and develop their rated power

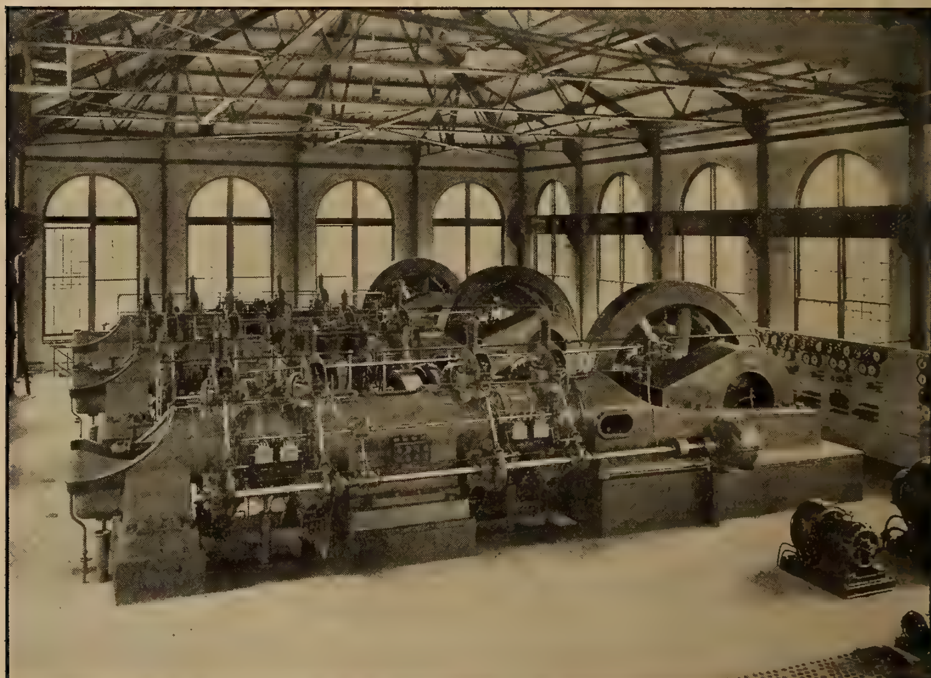


FIG. 7.—THREE WESTINGHOUSE ENGINES AT SWISSVALE, PA.

1,500-horse-power, 60-cycle power plant for industrial works service at the Union Switch & Signal Company, Swissvale, Pa. Designed for producer gas work. First installation in America to operate 60-cycle generators in parallel without spring couplings. Engine cylinders 23½ x 33 inches, 150 revolutions per minute, rated at 500 horse-power, 350 kilowatts on producer gas. Operating for the present on natural gas with limited governor control.

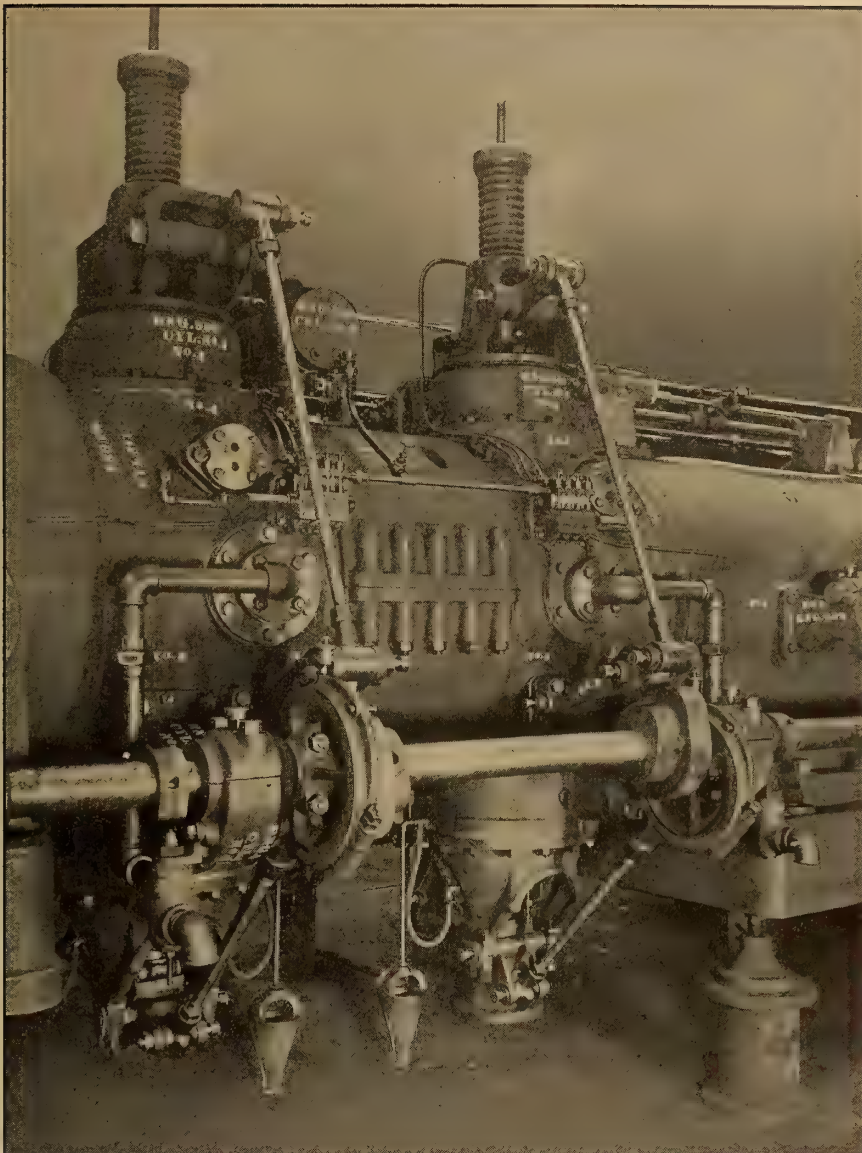


FIG. 8.—CYLINDER OF HORIZONTAL WESTINGHOUSE ENGINE

at 150 revolutions per minute. The engines are installed at the works of the Union Switch & Signal Company, Swissvale, Pa. (near Pittsburg).

These engines present a very symmetrical appearance, and the valve gear has been reduced to a mechanism of a simple nature. The inlet and exhaust valves are on the top and bottom of the cylinder and are both operated from a single eccentric, there being only two eccentrics to each cylinder. Suitably shaped rolling levers are used to ensure the proper timing of the valves. The inlet valve is of the ordinary mitre type, and carries with it in its up-and-down motion an annular valve controlling the air and gas inlets. The annular valve can be rotated

round the inlet valve-spindle by means of the action of the governor, and when at full load both air and gas ports are wide open; at partial load the rotation of the valve under the influence of the governor reduces the effective opening These cut-off valves are all connected together by means of reach rods worked from a small cylinder, into which oil under pressure is admitted by means of some small pilot valves directly controlled by the governor. A limiting device, somewhat similar to that used on steam steering gears, is attached to the oil cylinder, so that the travel indicated by the governor is not exceeded. The cylinders of these engines are cast in two pieces, the inner tubes of which are held together by T-shaped dowels. A broad space is left between the ends of the outer casing, and this gap is closed by a split band, which, when unbolted, gives access to the water-jacket. The general arrangement will be seen in Fig. 8. The makers state in their specification in the paragraph relating to regulation:

"Between no load and full load the mean speed vibration shall not exceed 3 per cent. either way from the normal speed for all reasonable and usual changes of speed."

The Southwark Foundry & Machine Company, of Philadelphia, Pa., is another well-known firm of steam-engine builders who have lately taken up large gas engines. The blowing engines built by this firm are fitted with a peculiar form of valve gear which has been extensively used in Europe, and when they decided to build gas engines their choice of design was awaited with much interest. The illustration, Fig. 9, shows one of their first large engines in course of construction. This is a

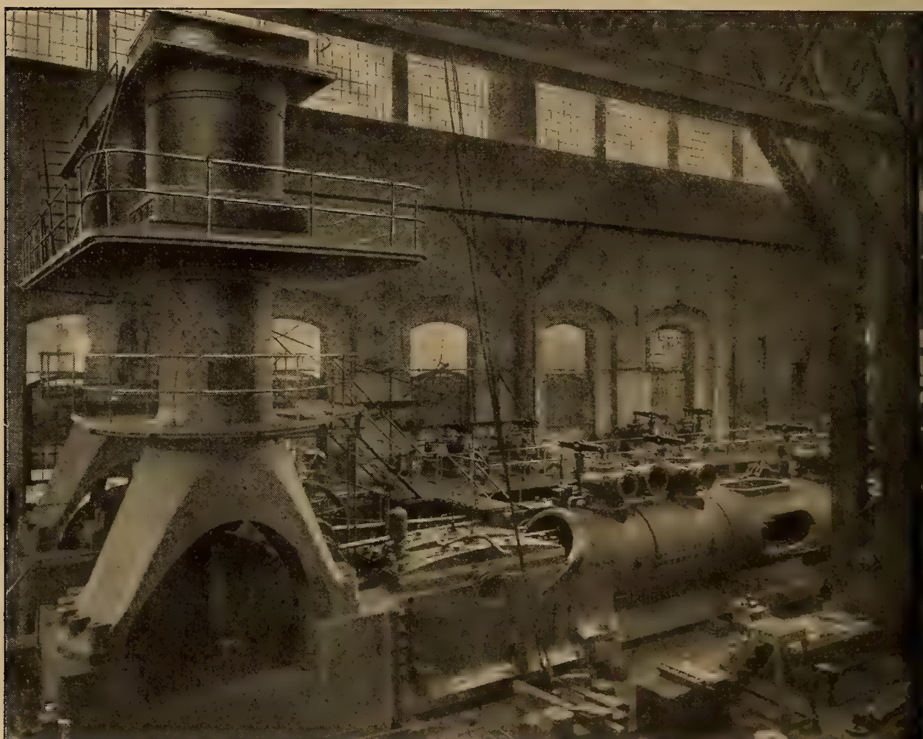


FIG. 9.—3,000-HORSE-POWER GAS-DRIVEN BLOWING ENGINE. THE SOUTHWARK FOUNDRY & MACHINE COMPANY, PHILADELPHIA, PA.

blowing engine of 3,000 horse-power with the blowing tubs placed vertically above the crankshaft. The engine itself presents several very novel features. A continuous bed-plate under the cylinder is used, and the exhaust valve is taken to the side, the valves being of the semi-balanced type. The valve box is placed at the bottom of the cylinder and the charge is swept out tangentically. The cylinders are made with the outer casings separated in the middle and covered by a split band, which seems to be the general American practice. Perhaps the most novel feature of the engine is the governing gear. In this case the cut-off valves are operated electrically under the control of a sensitive governor. In examining the details of this engine it will be evident that the makers have, to some extent, followed the experience gained in the construction of their Porter Allen and their Southwark steam engines.

So far, the vertical gas engine has not been built in sizes above 1,000 horse-power; indeed, the engine illustrated in Fig. 10 is the first, and so far the largest, yet constructed. This was put to work last year at the Weston-Point works of the Castner-Kellner Company, and was constructed at the Trafford Park works of the British Westinghouse Company from the designs of Mr. W. Stead. Although this engine was not intended to be built as an experimental one, as things turned out a very great deal of valuable experience was gained during the preliminary trials.

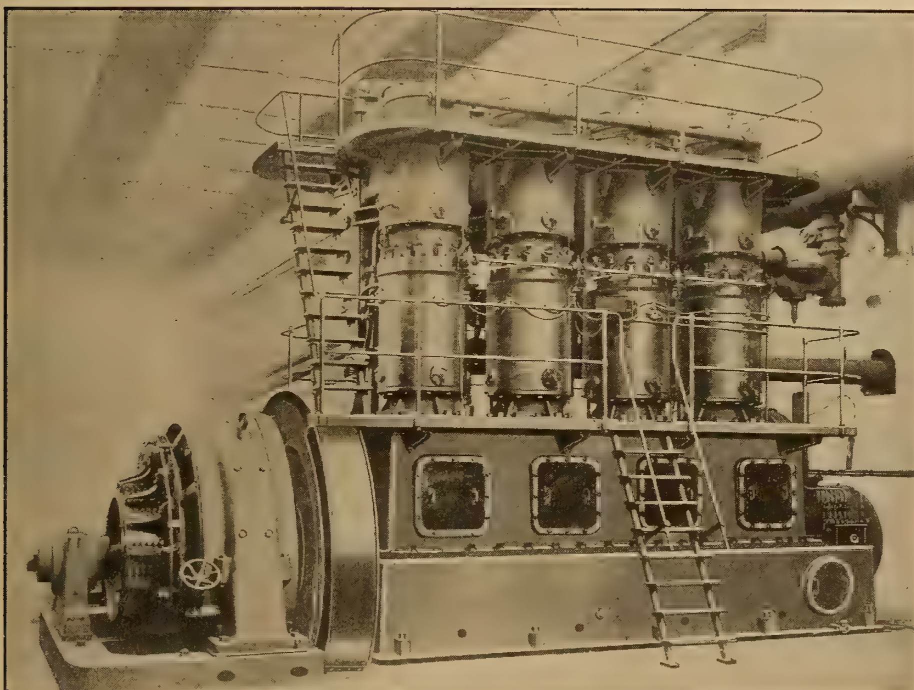


FIG. 10.—EIGHT-CYLINDER, 1,000-HORSE-POWER VERTICAL WESTINGHOUSE ENGINE

It has already been mentioned that the American Westinghouse Machine Company brought out some years ago a vertical, single-acting, three-crank gas engine using the Otto cycle, and the English company developed the idea by duplicating the cylinders and making the trunk pistons of two cylinders act on the same crank. A complete line of engines of this type

has been designed, the diameter of the cylinders being kept uniform, and the stroke and speed being the same throughout. Each line of cylinders represents a single unit of power, increased output being obtained by simply multiplying the number of lines of cylinders. In these engines the horse-power, two lines represent 500 horse-power, three lines 750 horse-power, and a four-crank engine with four lines or eight cylinders equals 1,000 horse-power. The upper and lower cylinders are separated by means of an intermediate head, which has a conical projection extending up

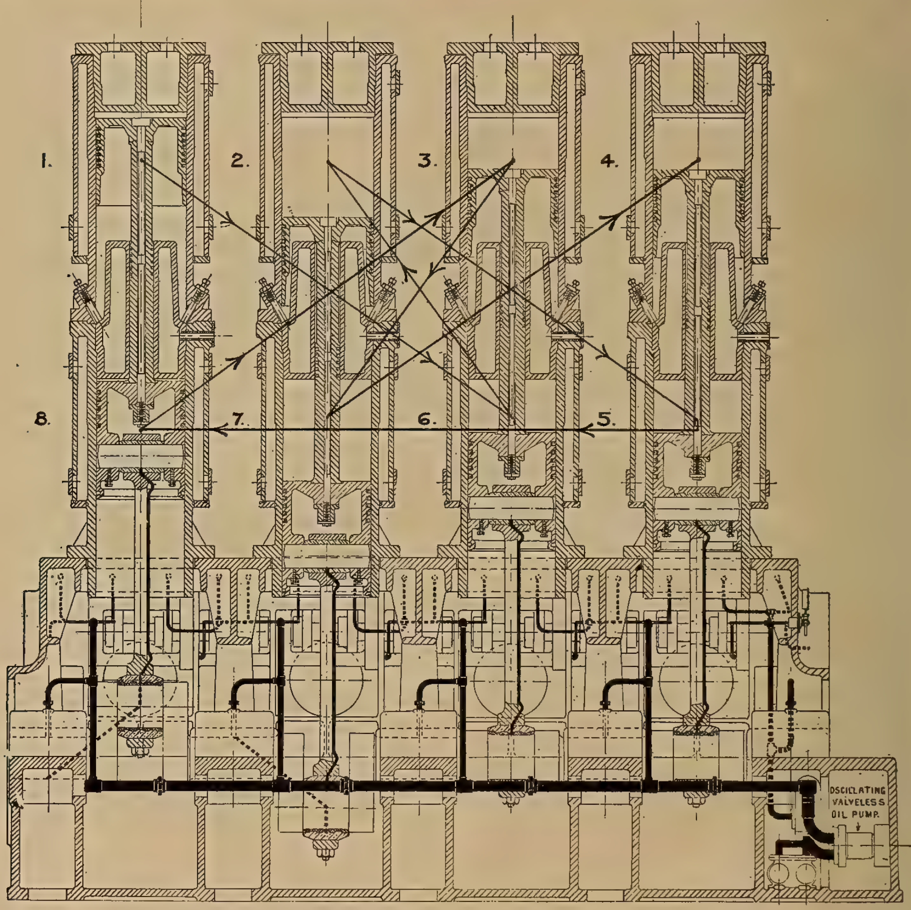


FIG. 11.—LONGITUDINAL SECTION OF 1,000-HORSE-POWER WESTINGHOUSE GAS ENGINE. SYSTEM OF FORCED LUBRICATION AND ORDER OF FIRING 1, 6, 2, 5, 8, 3, 7, 4

stroke is in all cases 24 inches, the speed 200 revolutions per minute or thereabouts, and the diameter of the lower cylinder 21 inches and the diameter of the upper one 22 inches. This difference allows the lower trunk to be readily drawn up and removed through the top cylinder. One line of tandem cylinders of these dimensions represents 250 brake- into the top cylinder, so as to obtain sufficient length to form a stuffing box. The upper and lower trunk pistons are separated by a cast-iron distance-piece and held together by a nickel-steel bolt, and the stuffing-box effect is obtained by a series of piston rings carried in the distance-piece. The upper part of the connecting-rod works in a gudgeon pin

in the lower trunk in the usual way. The bottom of the upper cylinder being closed in by the top of the intermediate piece, forms an air buffer to the top trunk, the pressure thus produced being so proportioned that it absorbs the inertia of the reciprocating parts; and that it has this effect is proved by the fact that these engines run very steadily without any counterweights on the cranks. The cylinders, top covers and intermediate heads are water-cooled; but it has not been found necessary to water-cool either the trunks or the exhaust valves.

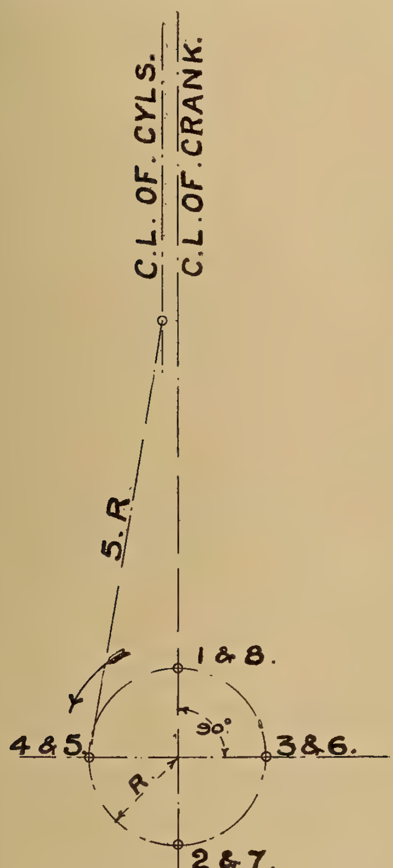


FIG. 12.—ORDER OF FIRING OF 1,000-HORSE-POWER WESTINGHOUSE ENGINE

In the 1,000-horse-power, four-crank size, each adjacent pair of cylinders have the cranks opposite one another, but the two pairs of cranks are at right angles. The diagrams, Figs. 11 and 12, explain this, and also explain the sequence of firing in the various cylinders. There is only one inlet valve and one exhaust valve to each cylinder, and these are worked in the simplest possible way from a 2-1 camshaft placed in the enclosed bed of the engine.

Forced lubrication is obtained from two valveless pumps worked off the crankshaft, and is used for the lubrication of the main bearings, camshaft bearings and both ends of the connecting-rod. The cylinder lubrication is effected by separate pumps with sight-feed lubricators. The governing is effected by throttling both the air and the gas.

So far high-tension ignition has been used on these engines, but the revision of the ignition question is now under consideration.

The writer had four of these engines, each of 750 horse-power, working for some time very satisfactorily; but when it came to put down the 1,000-horse-power engine with eight cylinders it was found that the plan of making all eight cylinders draw their supply of gas through one manifold did not answer, as it was found that the groups of cylinders most favourably situated with regard to the gas and air supply did the bulk of the work while the others were starved. This was overcome by dividing the cylinders into groups of four each and connecting them quite independently to the gas main and air inlets; that is to say, as far as the supply of mixture is concerned the engine might be regarded as being divided into two sections with the crankshaft common to both. It is a very debatable point as to how far this type of engine is suitable for large powers. Up to eight cylinders it seems a manageable machine and has much to commend itself for places where floor space is valuable. Comparatively inexpensive foundations are required, and none of the individual parts is of unwieldly

size. If the ignition is kept in good order it gives very even turning, and the fact that it has been successfully applied to cotton spinning proves this.

The consumption of gas per brake-horse-power is certainly as low as any other type of engine, and the lubricating arrangements require only a very moderate amount of oil.

On the other hand, the design involves in the larger sizes a multiplication of cylinders and a duplication of a number of small working parts, which, although simple enough individually, when combined present quite a number of points for possible breakdowns; and in the present state of the art it seems probable that, for land purposes and for powers above 1,200 horse-power, the tandem horizontal type of engine will, on the whole, be preferred. The writer has specifically referred to the Westinghouse engine, as up to now this has been the only vertical design in which 1,000 horse-power has been reached; but, at the same time, there are numerous other designs of vertical gas engines of smaller sizes operating very successfully in various countries; amongst others, the vertical gas engines of Crossley, Fielding & Platt, Tangye, and Campbell will be frequently met with, while on the Continent the Guldner vertical engine has come into considerable use, and in the United States there are quite a number of makers who build three and four-cylinder vertical engines up to moderate sizes.

In the present article the writer has only attempted to describe in a general way the chief points in the construction of the four-cycle engine as built in the larger sizes, and the question of large gas engines working on the two-cycle principle will be treated in a separate article. From the examples referred to and the illustrations given the writer thinks it may be considered proved that large horizontal gas engines up to 5,000 horse-power are well within the capabilities of experienced makers, and, from all accounts, such engines are working equally as well as reciprocating steam engines of the same size.

It was the intention of the writer to have described in the previous article the type of four-cylinder, double-acting gas engine made by the Swiss Locomotive & Machine Works, of Winterthur; but the necessary explanatory drawings and diagrams were not at the moment available. This company builds both vertical gas engines in the smaller sizes and double-acting horizontal engines for sizes up to 2,000 horse-power. These have single cylinders or two cylinders arranged either twin or tandem, or four cylinders placed twin-tandem; and an illustration of one of these twin engines is shown in Fig. 13, while Fig. 14 shows a cross-section of the cylinder and valve gear, Fig. 15 being a diagrammatic view of the latter. It will be seen that the engine presents a very compact and symmetrical appearance, and differs in several respects from general European practice. In the first place, the water jacket of the cylinder is made quite distinct from the working cylinder proper, and consists of a separate casing bolted on in halves; but the ends carrying the valve chambers are cast in one piece with what corresponds with the inner tube in the ordinary construction. This plan is common enough in America, but is not usually adopted in Europe, although in the Reichenbach engine a very similar arrangement is used. The front crosshead is made cylindrical and works in a bored guide; but while tailrods are provided, no exterior slippers are used at the back, nor is there any intermediate support at the junction of the two piston rods when the cylinders are placed tandem, but a considerable amount of support is given to the rods by means of extra long stuffing-boxes. Very complete automatic oiling devices are used, and careful provision is made for adequate circulation of the cooling water. However, the chief feature of in-

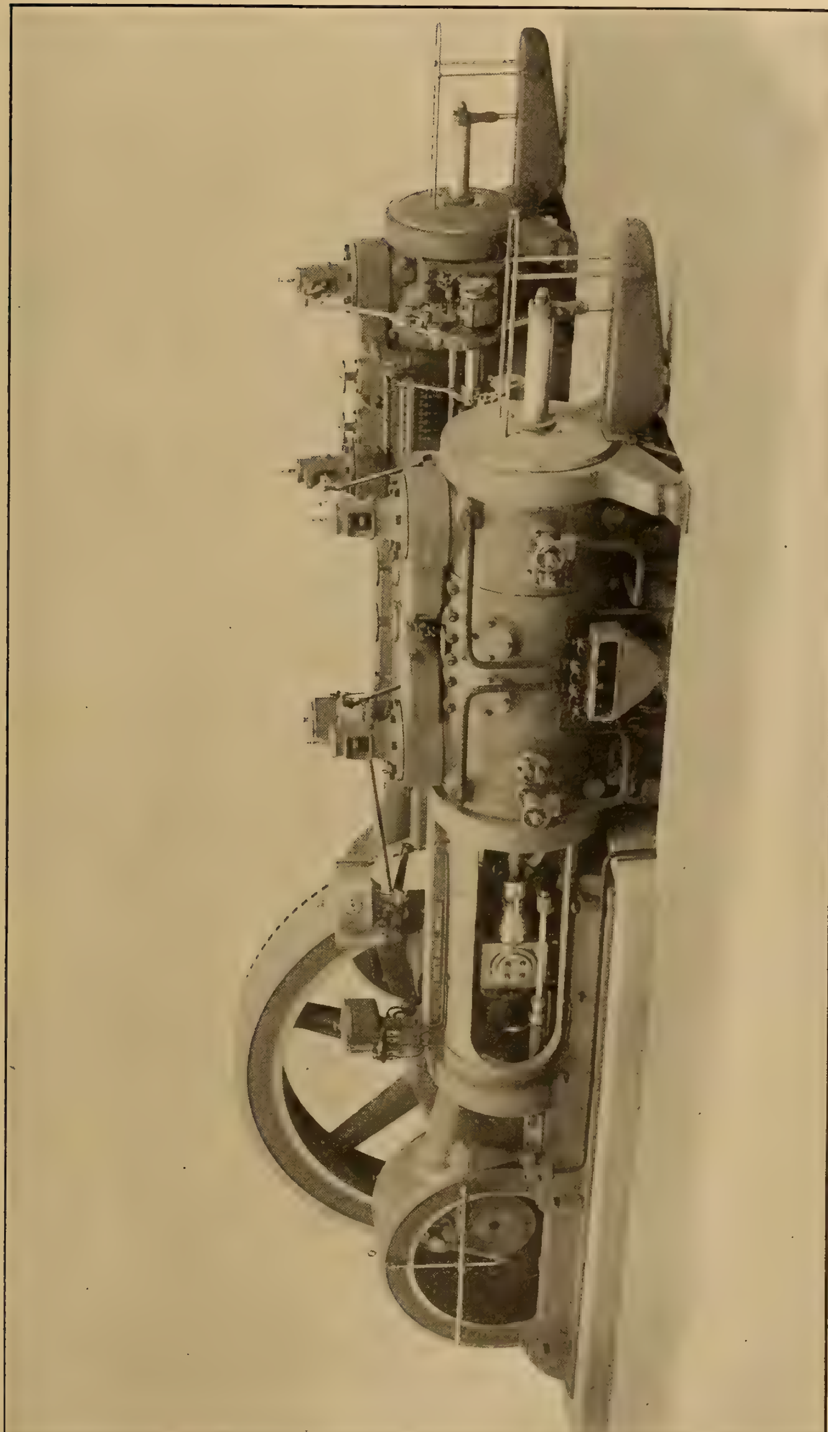


FIG. 13.—FOUR-CYLINDER, DOUBLE-ACTING GAS ENGINE. SWISS LOCOMOTIVE & MACHINE WORKS, WINTERTHUR

terest in the engine is the automatic valve gear and control of the air and gas supply. The inlet and exhaust valves are on the top and bottom of the cylinder opposite to one another, and only one eccentric is later during the stroke; but these valves always open at the same time, whatever the position of the governor may be. The arrangement for effecting this can be best seen by examination of the diagram, Fig. 15.

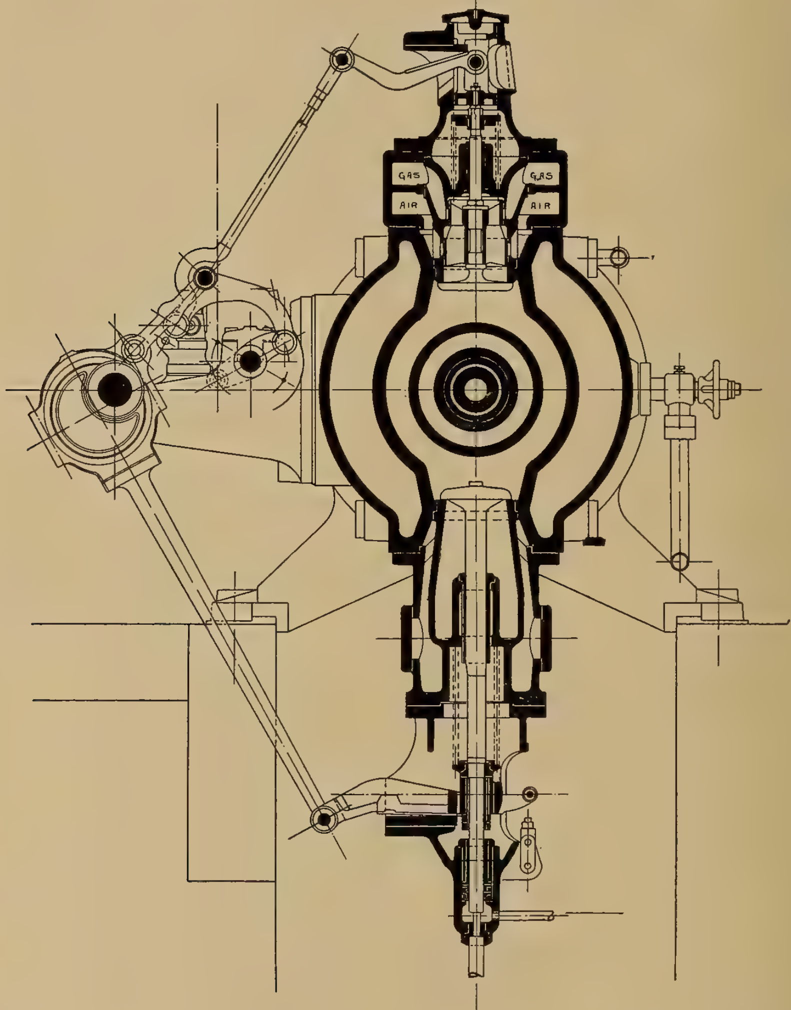


FIG. 14.—CROSS-SECTION OF CYLINDER AND VALVE GEAR OF THE SWISS LOCOMOTIVE & MACHINE COMPANY'S ENGINE

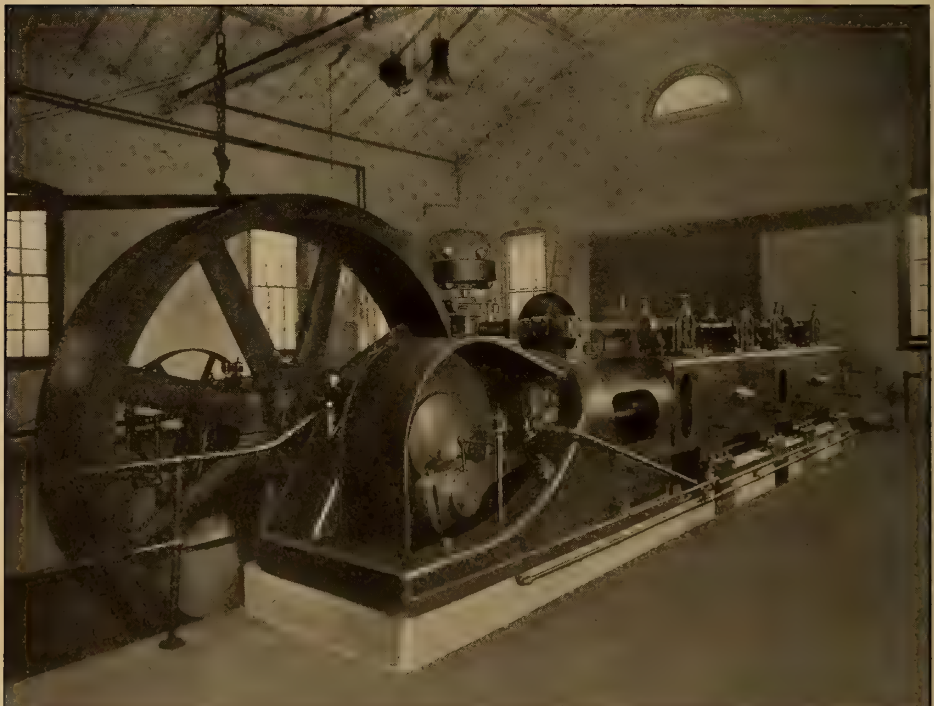
employed to control both the exhaust and the admission. The two piston valves which regulate the supply of air and gas are mounted on the stem of the inlet valve and move with it. Regulation is obtained by closing the inlet valve and at the same time cutting off the air and gas sooner or The eccentrics are keyed on the layshaft *K*, driven by 2-1 gear in the usual way, the reduction taking place partly at the crankshaft end and partly in the governor case. The exhaust valves are worked by the rolling lever *HI* connected to the eccentric strap by a rod *GH*. On the

same eccentric strap is fixed a pin *A*, whose centre describes an elliptic

FIG. 15.—SKELETON DIAGRAM OF VALVE GEAR. THE SWISS LOCOMOTIVE & MACHINE COMPANY, WINTERTHUR

curve and acts on a three-point lever *BCF* by means of a short connecting-rod coupling *A* and *B*. The point *F*, round which the lever *BCF* is swinging, is itself moved by the governor between the points 1, 2 and 3, according to the load on the engine. The stem of the inlet valve is

FOUR-CYCLE TANDEM GAS ENGINE, 300-HORSE-POWER, AT WORKS OF THE WATSON-STILLMAN CO., ALDENE, N. J. RIVERSIDE ENGINE CO., OIL CITY, PA.



RIVERSIDE GAS ENGINE AT WATSON-STILLMAN WORKS. OPERATING WITH STRAIGHT CARBON-MONOXIDE GAS FROM TAIT GAS PRODUCER

moved by the rolling lever DE, to which is connected the rod CH. The point C of the lever BCF is moving between $C1$ and $C2$, and the distance $CC2$ gives that part of the motion which corresponds to the opening of the valve after the lever DE has been touching the rolling surface R, the triangular-shaped curve passing through C and $C1$ gives the useful part of the motion of the point C at the different positions 1, 2 and 3 of the governor, the points 1-2-3 on the elliptic path described by the point A shows the moments the cut-off takes place for different positions of the governor, and the distances 1-2 and 1-3 represent the times during which the inlet valve is opened, while for all positions of the governor the time of opening of the valve begins at the point 1 of the elliptic path of the point A. Although the description is not easy to follow, the gear itself is very simple, and is a rather elegant arrangement for getting a variable movement of the valves without the use of trip gear. Arrangements are made for varying the proportions of air and gas by hand in the usual manner, and at very light loads the mixture is made somewhat richer, to ensure prompt and satisfactory ignition.

The method of regulation is, of course, quantity governing; that is, the composition of the mixture remains constant; but the quantity admitted each stroke is varied, according to the indications of the governor. Quality governing has already been referred to in the previous chapter.

Unfortunately, a certain amount of ambiguity exists as to the exact meaning to be attached to the expressions "quantity" governing and "quality" governing; but a very full discussion of the subject will be found in the various writings of Prof. Mathot. However, as has previously been said, the matter ultimately resolves itself into how much gas is admitted each suction stroke.

MODERN POWER STATION DESIGN

By H. de B. Parsons

THE present tendency is to concentrate power generation into large central stations. This has been brought about by the economies that can be obtained from large power-generating units, from savings in cost of supervision, and through the ease of transmitting the power in the form of electrical energy to the points where it has to be used.

The power can be generated either by steam engines or steam turbines; by internal-combustion engines, using oil or some form of producer gas, or by hydraulic turbines.

Hydraulic power developments must be located at the source of water-power, and are frequently assisted by a steam plant. These developments form a special study.

Internal-combustion engines with ratings as high as 4,000 horse-power are at work. Their use has not yet become general, owing to troubles experienced in the larger sizes from deposits of carbon on valves and ignition apparatus; from speed control, especially with alternating machines in parallel; from back-firing, and other difficulties.

It is best, therefore, that this article be confined to steam-driven plants, as they are by far the most numerous.

The so-called "isolated" power plants in many industrial works and in some large office buildings and hotels compare in capacity very favourably with many "central" stations in the smaller communities.

The cost of electric generation at the switchboard of the central station is sometimes less than the cost of delivering the current outside of the station building. Large isolated plants, using the exhaust for heating during five or six months a year, can frequently generate electricity at a lower cost than that at which the same current can be purchased from a central station.

When comparing costs between isolated plants and central stations a word of caution will not be out of place. All central stations are equipped with recording meters, while many isolated plants are not. In these latter the output is assumed or guessed, and frequently assumed too high. As the unit cost is obtained by dividing the total expenses by the output, the result is apt to be too low.

SITE

It frequently happens that the engineer is limited in the selection of a site, as an ideal site cannot always be secured. This limitation refers both to location and to shape of the land.

For power-station work, where the power has to be used outside of the generating building and frequently transmitted long distances, a central station is the ideal one. Centrally located stations effect economies in first cost of transmission, in reduced losses in the transmission system, and consequently reduced cost of operation.

When the station is located in open country almost any dimensions can be given to the building, and as economies can be secured by allotting suitable relative positions to the different pieces of apparatus, this freedom from restriction in shape is always a favourable condition.

When the station is located in a city the shape of the plant, in plan, must coincide with the outline of the

block selected. This restriction governs the location of the machinery and limits freedom of design.

The principal physical conditions other than that of central location which govern the selection of site are facilities for receiving fuel, for removal of ashes, and for obtaining water for condensing purposes.

The situation should be such that the plant will not be flooded during periods of high water. If there is likelihood of flooding, the elevation of the basement floor should be designed high enough to remove all danger.

Another point should be mentioned, namely, care to avoid and prevent damage suits from neighbouring property. Such complaints are generally based on the ground of nuisance caused by coal and ash handling, smoke and soot, and vibration. Therefore, the character of the neighbourhood and uses of adjacent houses often affect the choice of a site. All running machinery will create vibration. The engines should be on massive foundations, which should be absolutely independent of the walls of the building. It is sometimes well to place a sand cushion around these foundations to absorb any tremors that are liable to start. The engine-room floors are frequently of concrete, but should not touch the foundations, lest they transmit the vibrations to the building walls. The design should cover these points to best advantage, so that the station may not be judged a "nuisance."

The cost of the property and the cost of filling, grading or otherwise preparing the land for the erection of the plant are also prime factors for consideration. The interest on this cost becomes an item in the annual fixed charges, which must be paid out of gross income before any net income can be figured. Furthermore, the interest on the purchase price and cost of land improvement during the period of construction is really a charge against construction account. Such a charge is frequently overlooked when preparing estimates, although it sometimes happens that this charge amounts to an appreciable proportion of the total cost of actual construction work.

In planning the general arrangement, the most difficulty will be found when the area of the site is restricted by fixed dimensions.

The machinery should be arranged symmetrically, as a much neater appearance is thus produced. When the interior, as well as the exterior, of a station is made attractive, the operators unconsciously take more pride and pains to keep the plant trim and in good running order. It costs no more to make an attractive design than an unattractive one, and yet from a business viewpoint much will be gained thereby. Another great advantage in a symmetrical arrangement is the facility of making cross connections, so that any boiler, engine or machine can be shut down or cut out of the system for repairs without prejudice to the rest. Also, the cutting out of a unit in cases of accident can be more quickly done, and with less chance of error in reaching the proper valves, if the layout is symmetrical. When corresponding pipes and valves of different units are placed haphazard, quick work at times of accident is almost impossible.

The station can be divided into the boiler department and the engine department. The boiler department contains the boilers, the firing space, the pump space for feed and service pumps, the coal bunkers, the coal-conveying apparatus, the ash storage and the ash removal space.

The engine department contains the main machinery and auxiliaries, and can be divided into the main engine space, the condenser space, the auxiliary machinery space, the electrical space (switchboards and transformers), the office and employees' space.

These spaces do not have to be separate rooms, although some may

be walled off for convenience. Generally speaking, it will be found most convenient to divide the building by walls or floors, so as to separate the different grades of employees, as well as to keep the dust of the coal and ashes from the machinery. The amount of floor space required depends on so many considerations that it is not possible to give exact data. One of the main items is the type of prime mover and generator selected. Thus a horizontal Corliss type of engine requires more floor space and less height than a vertical engine, and the steam turbo-generators require the least space. The same is also true of various types of boilers.

The data from a number of stations give the following average floor space required per rated kilowatt capacity:

	Floor Areas.			
	In Square Feet.		In Per Cent.	
	* R.	T.	R.	T.
Boilers, flues, feed pumps	1.43	1.08	34.8	28.8
Coal storage and conveyor	0.43	0.58	10.5	15.5
Ash storage and removal	0.24	0.40	5.8	10.7
Engine and generators				
Condensers and auxiliaries	0.56	0.56	13.6	15.0
Electrical equipment	0.33	0.44	8.0	11.8
Office, employees	0.13	0.12	3.2	3.2
Total	4.11	3.74	100.0	100.0

* R denotes reciprocating engine. T denotes turbine.

The floor area per kilowatt in very large stations will be smaller than these averages. The cubical contents of the buildings vary in turbine stations from about 85 to 170 cubic feet per kilowatt, and in reciprocating stations from 85 to 250 cubic feet.

In preparing a general plan it is well to arrange the parts for future enlargement. In other words, make the layout large and so arranged that a part can be omitted without deranging the remainder. Then the part so left out can be constructed later as an addition, and the machines will fit in their proper places and be symmetrical.

BUILDING

The shape and size of the building are dependent on the dimensions of the land and the present and probable near-future capacity. While the arrangement is very variable, nearly all modern stations have certain features in common; thus, two bays or divisions, one for boilers and one for engines; with limited area of land, the floor space required is obtained by additional floors; the structures are of fireproof construction, and some attempt is made toward good architectural appearance.

The architecture of the exterior of the building should be suitable for and in harmony with the neighbourhood. The design must necessarily be a medium between pure artistic merit and utility. Generally speaking, the architect desires the former and the engineer the latter. Each must waive something and produce a building that will not interfere with economy and convenience of operation and still be a credit to good taste. It is no more difficult to design a line of grace than one of ugliness.

In general, the most attractive buildings are those which are so planned as to permit an odd number of panels in the exterior walls. Where ground space is limited, the boilers are placed on different floors, one over the other, and condensers and pumps under the main engine floor.

CAPACITY OF STATION

The amount of generating capacity that should be installed in any station can only be determined after careful investigation based on experience and good judgment.

The maximum power required comes upon the station at times of peak loads, and these peaks may only last a short time. When the peak periods are sufficiently short, the

work may be carried by the overload capacity of the machinery. All good electrical generators will carry an overload of 33 per cent., when properly ventilated, for, say, two hours. Engines will take a considerable overload, depending on the valve arrangement; but at reduced economy as the load exceeds the rating. Steam turbines are capable of running at loads exceeding their ratings, which ratings are nominal ratings of capacity. The "station load-factor" is the ratio of the average output to the rated capacity of the plant, and its value is dependent on the spare units installed. The "load-factor" is the ratio of the average to the maximum output, and should be based on a year's operation.

Load-factors are very variable, depending largely on the work that has to be done, the nature of the industries and people, the shape of the territory, and the nature of the adjacent country.

As a guide, these factors have values about as follows:

	Approximate Station.	Load.
For electric railway service	0.35 to 0.45	0.40 to 0.60
For electric lighting service	0.15 to 0.25	0.25 to 0.40

When designing, it is difficult to predict the average load. There is always a tendency toward assuming a too high average load, but a station equipment which is given too great a capacity is less serious a fault than one which is given too little.

After having determined the total capacity, the size of units must be selected. The capacity of each unit should be such as to give the widest scope of operation as regards variable output and still have units operating at near their rated powers. For convenience, each unit should be of the same capacity, although this is not necessary.

PRIME MOVERS

Most modern central stations generate electric current, the prime movers for which are either steam engines or steam turbines.

It is not possible to state which should be used, as the choice depends on local conditions and on the kind of service. Steam turbines have been introduced only during the last few years. They have done good work, and, not having any reciprocating parts, are free from practical troubles inherent to the reciprocating engine.

Engines may be either vertical or horizontal. Vertical engines, generally speaking, are the most desirable for large powers and require less floor room.

Comparing engines and turbines, we find that (a) the turbine requires less floor space, but must have its condenser placed close to it for best effect; (b) the turbine economy is less affected as the power departs from the normal rating; (c) the speed of rotation of the turbine is much higher than that of the reciprocating engine; and (d) nearly all large stations are now being built for turbines.

All large plants are now made condensing. With turbine plants very high vacuums are maintained, as turbines can utilize high vacuums to better advantage than reciprocating engines.

The amount of steam consumed by the prime movers per kilowatt-hour varies with the size of the unit, the character of the service, the constancy of the load and the load-factor.

High-grade reciprocating engines of the multiple expansion type, running condensing, use from 15 to 20 pounds of steam per kilowatt-hour, and steam turbines from 14 to 17 pounds, both under test conditions. In practice the difference is not so great.

Steam must also be provided for the auxiliaries and for the losses incident to an operating plant. Auxiliary steam is not far from 8 to 10

per cent. of that required by the prime movers. For leakage past valves, pistons and through drips, and for "warming-up" the units prior to cutting them into service, an additional allowance of 10 to 12 per cent. should be made.

It has been found that many generators will operate continuously at capacities greater than their rating. This has produced overloads on the engines and a departure from the most economical conditions. It is no easy matter to proportion a large unit so that the engine and generator will operate at maximum economy at the same time. In some stations the generators are under steam-powered, while in others they are over-powered, both of which conditions are detrimental to good working results.

BOILERS

The boiler capacity of a plant should be divided into batteries, one battery for each unit, with spare boilers for each battery. The boilers are made the same size, and the size selected is the one which will best fill the space allotted and still be as large as the particular make of boiler will permit for all-round convenience. As the steam pressures used are high, all large stations use boilers of the water-tubular type. Each battery frequently has its own stack, but this separate stack arrangement is not an essential feature.

Each boiler should be so piped and connected that it can be cut out for any purpose without affecting any of the others. As accidents to the boilers are liable to happen at any time, this point is very essential, and little things often are of considerable value in making a plant easy of quick handling.

There should be plenty of boiler capacity, as there is no economy in cramping the plant in this particular. The ratio of heating surface to grate surface should be large, approximating 40 to 1, that the heat of combustion of the fuel may be absorbed before the gases reach the flue.

SUPERHEATED STEAM

The use of superheated steam is based on correct thermodynamic principles. The object of introducing superheat is threefold—the steam acts more nearly as a perfect gas; it is a poorer conductor of heat than wet steam; and it can lose heat through performance of work and radiation before it becomes saturated or wet. Internal condensation, which constitutes one of the chief losses of heat in the steam engine, is, therefore, greatly reduced. In practice, the reduction in steam consumption by superheating is about the same in both reciprocating engines and turbines.

The economy derived by the proper use of superheated steam appears to vary, according to conditions, from nothing to 15 per cent. of the fuel required in large power stations. It also appears that, with superheated steam, the amount of steam required per indicated horse-power is less dependent on the size of the engine, or that small units use about the same weight of steam per horse-power as large ones.

The greatest benefit with the least complication is obtained with steam heated to a temperature not in excess of 550 degrees Fahr. and with a pressure of about 160 pounds per square inch. The amount of superheating surface required is difficult to determine in advance. In practice, its amount is very variable; but is seldom less than 10 per cent. of the water heating-surface, and is often more if it can be conveniently worked into the design.

The cost of superheating surface is nearly the same as that for an equal amount of water-heating surface.

With high-temperature steam steel piping, valves and fittings are used, and all composition valves, castings, etc., are eliminated.

AUXILIARIES

In every station there are a number of auxiliary engines and ma-

chines which are necessary for the operation of the plant. These are nearly always of standard make and sizes. Their selection and location in the plant are important, as their functions are such that the main engines or boilers cannot operate without them.

Where possible, these auxiliaries should be made interchangeable in operation; that is, an auxiliary should be made to operate with any unit. The system of cross connection should not be carried to an extreme, so as to introduce too many complications, or the utility of so doing will be defeated.

The condensing apparatus is all-important. Condensers are of both the surface and jet types, the selection depending on local conditions and details. Where feed-water is scarce, expensive, or of a scaling character, surface condensers have many advantages over the other type, although they are more complicated and demand greater floor space. With surface condensers using circulating water which is salt and contaminated with sewage and impurities from industrial establishments, the brass tubes corrode and ruin the vacuum. This corrosion appears to be some de-zincing process, either chemical or galvanic, or both.

My experience with bad water, acid in character, is that the tubes are best made of admiralty composition, namely, 70 parts of copper, 29 of zinc and 1 of tin.

It is essential that as high a vacuum as possible be obtained, and this is more true with turbines than with reciprocating engines. A very high vacuum with a surface condenser can be mantained by using a "dry" vacuum pump in addition to the regular air pump. The function of this "dry" pump is to remove the vapour, which the air pump does only partially.

The main feed pumps are best connected into a feed-water main common to the battery of boilers, and from which branches can be led to each boiler. On the feed main there should be a relief valve, so that it cannot be burst by excessive pressure.

Many of the auxiliaries could be operated electrically. In practice, it is found advantageous to make them steam-driven, as the exhaust steam is wanted for feed-water heating.

PIPING

A most important feature of every station is the piping plan. The boilers, engines and pumps are of standard manufacture, designed by the makers. Their correct and economical operation depends on the piping and connections. Steam pipes should be of ample size. Their area should be such that the average velocity of flow does not exceed ordinarily about 8,000 feet per minute. For large units, this velocity will require very large pipes, and higher velocities are then assumed as a compromise. Velocities have been used as high as 16,000 feet per minute. The objection to a high velocity is the loss of pressure due to friction, and the designing velocity for pipes must be selected from experience.

Duplicate piping systems are not necessary when the piping plan is well designed.

Pipe failures are caused by poor design, carelessness or neglect, and seldom by weakness due to using too thin material. Many failures are traceable to lack of provision for expansion and contraction, and to the movement caused by vibration of the running machinery.

Ample allowance should be made for expansion. The simplest method is to provide bends with easy turns in the line of piping, or to use fittings with long radii. Slip-joints, generally speaking, are a nuisance. It is best to avoid them where possible, as they are liable to give trouble.

Pipes are best anchored at the center of straight runs. Expansion will then be divided and can be taken up by bends on the branches. Horizontal headers should pitch toward the end,

which can terminate in an elbow turned downward with a vertical piece attached to form a water leg. This leg can be blank flanged and drained through a trap.

Pipe lengths are best joined by flanges on all pipes over 2 inches in diameter. They should be of standard sizes, accurately fitted, and made interchangeable. The flanges for high-pressure lines are made of steel forgings or of open-hearth steel castings.

With superheated steam screw flanges should not be used. It is better to use Van Stone flanges, in which pipe ends are bent or flared over the inside edge of the flange, or else have the flanges welded on. The gaskets are generally made of corrugated copper, of soft Swedish iron with "smooth-on" cement applied, or of bronze or copper surrounding asbestos. Copper gaskets are liable to suffer from a pitting action. For high-pressure mains the flanges are faced and scraped, so as to fit metal to metal.

All steam valves over 2 inches in diameter, except the main stop valves on the boiler, are usually gate valves; but these should never be placed with the stem looking down. The bodies of the valves are frequently made of cast steel fitted with nickel-bronze seats. Cast iron is liable to change in shape when continually heated to high temperatures and subsequently cooled.

OILING SYSTEM

All running machinery must be kept lubricated. In a power plant, with its multiplicity of journals and rubbing surfaces, the cost of the lubricating oil and of the labour necessary to watch and attend to each oiling device is large.

In any bearing the amount of oil required to keep the bearing in good condition and prevent excessive wear is not great, provided each particle of oil could be made to do its share of the work. In other words, the amount of oil actually "used up" or vaporized is small. If the oil is fed to the surface, drop by drop, in such small amount, it will not be sufficient to prevent heating or wearing by grit. Practically the oil must be fed in greater quantity and be allowed to overflow from the bearing. Unless caught and utilized, this overflow of oil would be wasted. With vertical engines, the quantity of engine oil used is about one gallon for each 100 indicated horse-power per twenty-four hours.

Oil passing through the bearings often picks up considerable condensed moisture, resulting in the formation of an emulsion, which, together with the grit it carries out from the bearings, renders it unsuitable.

Oiling systems are now designed with the object of reducing the labour of attendance and saving the oil drips by filtering, so as to restore the oil for continued use.

The principle involved is the placing of an oil storage reservoir sufficiently high, so that it can run by gravity through pipes to all the bearings or surfaces requiring lubrication. The drips are caught and piped to a filter, from which the oil is pumped back to the reservoir.

These continuous oiling systems have proved economical, and make a cleaner engine room than one using oiling by hand.

Naturally, the different kinds of oil must have separate systems. In turbine stations, where oil is used to float the bearings, a special system is employed. As in this service the quantity of oil used is large, the reservoir tanks have been made 8 or 9 feet in diameter by 15 feet deep, which may serve to illustrate the importance of this feature of the plant.

For cylinder (internal) lubrication the finest, high-flash mineral oil should be used, and as little of it as possible. The quantity is about one gallon for each 1,800 indicated horse-power per twenty-four hours.

Vertical engines are frequently

operated without cylinder lubrication, as the cylinder condensation is all that is found necessary.

COAL STORAGE

In the majority of modern power stations of large capacity, economy of room is sought in every direction. Frequently sufficient storage room for coal is lacking, and to make up this deficiency the stations are located at places where coal can be constantly supplied. Just what is a "sufficient" storage capacity depends on many conditions, but the chief factor is the reliability of obtaining a continuous supply. If coal can be brought to the plant daily, or every other day, without danger of serious interruption, it would not be wise to use high-priced land for storage sufficient for a long period. The storage space would then only have to be of a capacity to run the plant for a period to tide over any ordinary interruptions in supply.

To economize floor space and to utilize gravity for coal distribution, the storage space is generally located over the boilers and under the roof. The coal is hoisted into the bunker by some coal-conveying apparatus, generally of the endless chain, bucket type, which both elevates and automatically dumps. The floors are inclined, so that the coal slides by gravity into pipe ducts, which discharge the coal in front of the individual boilers or into the hoppers of the mechanical stokers.

In cross section the bunkers resemble the letter W when the boilers are arranged face to face with an alley between them. The object of the slopes is to induce all the coal to flow into the pipe ducts, and this constant movement tends to prevent spontaneous combustion of the coal in the bunker. The slopes are at about 40 degrees from the horizontal.

ASHES

In the design of every station considerable ingenuity has to be used to provide a simple method for handling the ashes. It is generally customary to design each boiler ash-pit so that the ashes can be dumped directly through a hopper into ash cars. These ash cars operate on narrow-gauge tracks in the basement, or floor directly beneath the lower tier of boilers. After being loaded, the cars are run to one end of the building under a hoist, which lifts and dumps the car bodies. The arrangement for ash removal must necessarily be worked out to apply to the local conditions surrounding each individual plant. The quantity of ashes to be handled is always large; thus, in a 40,000-kilowatt station apparatus to handle, perhaps, 70 tons every day would have to be installed, as it is seldom found that any room is available for ash storage.

METHODS OF REDUCING LOSSES

In every station operated by steam losses of heat mean direct losses of power and increased cost of operation, because it is the heat units in the steam which are transformed into mechanical energy. Every effort is, therefore, made to conserve the heat.

With the boilers, the chief loss of heat is that passing off with the gases of combustion. With the engine or turbine, the chief loss is the heat rejected in the exhaust. In order to save the former the gases are passed through a feed-water heater in the smoke flue between the boiler and the stack. Such heaters are called "economizers," and when of proper size will reduce the temperature of the gases to about 300 to 350 degrees Fahr. If the plant is operated by natural draft, the temperature should not be reduced too low, or there will not be sufficient heat to create a good draft. Economizers have an advantage in the reserve of a large body of hot water for use in a sudden call for steam. The cost of an economizer is about equal to that for the same amount of boiler heating surface, but it costs less to keep in repair and no more to keep clean than boiler surface of

equal area. With feed-waters having bad scaling properties, these flue heaters are apt to give trouble unless surface condensers are used.

The heat rejected in the exhaust steam can be saved in part for feed-water heating, although a large portion must be lost through the circulating water of the condenser.

Little things often add to the general economy of a station. Thus, if a colour scheme is adopted for painting the pipes and pipe coverings, great convenience to the operating staff will result. It is not difficult to select colours to indicate at a glance the uses to which the pipes are put.

STORE ROOMS

In addition to the room required for machinery, coal and ashes, some space has to be set aside for the general station stores, such as oil of various kinds, waste, spare parts, tools, etc. In some stations a small shop equipment is installed for making light repairs. The amount of room required is not a great proportion of the total floor space, but for general station convenience its allotment often necessitates care. Some of these stores, like the lubricating oils, are inflammable, and some thought should be given to the fire hazard.

CONVENIENCE FOR WORKMEN

Nearly all large modern power stations are 24-hour plants, in which the men work in shifts. Conveniences should be given them for washing, and lockers for holding their clothes. Suitable lockers are made of open-work metal, which are clean, sanitary and durable. In large stations it is best to have separate rooms for the different classes of workmen.

For day working the windows and skylights should be so arranged as to give all the diffused daylight possible. At night the station should be artificially illuminated to best advantage, using arc lights for general illumination and incandescent lamps for detail illumination.

MANAGEMENT AND RECORDS

To operate a station economically, there should be a constant watch for leaks. There are leaks everywhere, from the roof to the foundation, and the only way to obtain a creditable result is by eternal vigilance. The men should have systematic duties to perform, and the heads of each department should see that each one does his work.

A complete daily performance of the station should be kept in tabular form, with record sheets in sufficient detail to locate leaks when discovered. Comparisons of these records, by days, by months and by averages, often unearth conditions which can be remedied. Frequently a graphic chart will be most instructive.

The station machinery becomes "old-fashioned" before it wears out, and simultaneously its economy falls below that of newer standards. In other words, the cost per unit of output exceeds that where more modern apparatus is used. In consequence of the machinery becoming out of date, the value of the plant should be regularly charged with depreciation according to some fair, yet liberal, system, and these depreciation charges should be made against gross earnings. They are just as much an operating expense as charges for labour and supplies.

The same end is reached if a certain sum is set aside each year into a "replacement fund," and all legitimate expenses for buying new machinery charged to this fund. Ordinary repairs should not be so charged. The sums set aside for this purpose should be sufficient to renew the whole plant, exclusive of land and grading, at the end of a certain period so selected as to represent the life of the plant.

Generally speaking, the safest way to keep the records is to directly charge depreciation against earnings, and to carry a sufficient surplus after paying dividends to meet replacement expenses at cost.

SKIMMING BOATS

By C. Johnstone

THE idea of decreasing water resistance by substituting for the ordinary hull of a ship a flat surface sloping gradually upwards at the bows is, perhaps, as old as the steamboat itself. Naturally, however, no fixed degree of inclination could be preserved with a vessel built on these lines, and at a very early speed the lift of the bows and declination of the stern would render the management of the ship impossible.

It was not, therefore, until some practical modification of this system was forthcoming that the use of an inclined surface could be successfully exploited to obviate the waste of energy resulting from the wave-raising of an ordinary ship's hull.

In the year 1872 the British Admiralty had before them the invention of a Rev. C. M. Ramus, of Rye, Sussex, who had conceived the idea of using two wedge-shaped bodies, one at the forward and the other at the after end of the vessel, affirming that this double wedge would give the necessary stability by providing that while the bow was lifted by the foremost of the inclines the stern would be lifted by the after one, the planes being placed in such a position in relation to each other that the ship would always keep her proper trim. Several models built on lines suggested by Ramus were tested, and, although the results obtained did not convince the Admiralty officials that they were relevant to the operation of the principle on a large scale, they were sufficiently remarkable to demonstrate its practical employment in small vessels of high power.

In the models submitted to test it was evinced that the two inclined surfaces did mutually support each other, the models when drawn through the water at high speed being lifted fore and aft simultaneously, the proper trim being maintained throughout.

Ramus designated his inventions "Bisphenic," or double-wedged ships; but later, as he increased the number of planes to three, "Polysphenic," or many-wedged.

In these early days the light, high-powered marine engine had, of course, not materialized, and the construction of small vessels embodying the results of Ramus' experiments were probably not considered.

Of recent years, however, quite a number of small vessels, built primarily for racing purposes, following very closely these early models in essential respects, have been evolved, usually termed "hydroplanes," having two or more inclined surfaces, and some very remarkable speeds have been attained with them.

This high speed is accounted for by the fact that such vessels glide over the water with comparatively small resistance, being lifted by the action of the fluid against the inclined planes of which the bottom of the vessel is composed. When the water strikes any part of these oblique surfaces it must either be driven vertically downwards, or it must escape laterally, or it must lift the boat vertically upwards.

When the vessel is at rest and floating in the water the wedges are submerged, and while the speed of the vessel is moderate they still remain submerged; but as the speed

increases the action of the water gradually causes the whole vessel to be lifted bodily until at high speed the area exposed to frictional action is simply the residuary under surface of the planes which supplies the support, since the speed of transit almost entirely denudes the sides of contact with the water.

If the water were irremovable the ship would of necessity be compelled to rise over it; but the water is removable, and will escape laterally if time enough be given for its removal. Consequently, when the vessel's speed is low the water has time to escape to one side or the other, and no lifting takes place; but as the speed increases, the time in which the escape of the fluid must take place is shortened exactly in proportion to the velocity of the boat; and as less and less time is given for the escape of the water, less and less of the water escapes from under the inclined planes, and the water which cannot escape becomes a firm support over which the boat glides.

For vessels of large size it has generally been held that the hydroplane principle is impracticable, primarily because of the great power required to raise the hull to the surface of the water, and also the difficulty of ensuring stability; but with the great progress in all things appertaining to marine development it has for some time seemed feasible to those who have interested themselves in the problem that present-day engineers would find it possible to utilize at least some modification of the principle in future boat design.

This being the case, it will not cause surprise to hear that an engineer by the name of W. H. Fauber, who now resides at Nanterre, France, and who has gained a considerable reputation there, and previously in the United States, as a clever inventor, has come forward with a proposition, backed by many patents, to construct large boats of a skimming order.

FIG. 1.—THE BROOKE, AN ENGLISH-BUILT HYDROPLANE RACING BOAT. THE J. W. BROOKE CO., LOWESTOFT

The Fauber hydroplane boat, above water, may have the appearance of any well-designed boat. The bottom consists of a number of planes conforming to the shape of the sides of the boat. These planes have a peculiar form in cross section that it is claimed give great stability, the con-

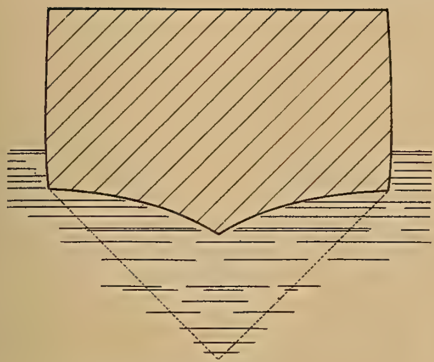


FIG. 2.—CROSS-SECTION OF "MAURETANIA" HYDROPLANE

tour being of a particular shape to secure the desired lifting power.

Dealing first with the question of the practicability of a large vessel being made to skim, let us consider the application of the principle to, say, a hydroplane *Mauretania*.

If two steel plates—one 4 feet square (the width of a 26-foot hydroplane) and the other 88 feet square (the width of the *Mauretania*)—were suspended flat on the surface of the water, and both released at the same instant, the small one would, as any engineer knows, sink much quicker than the large area, and with much less resistance. In the case of the hydroplane, the large surface not only, so to speak, sinks slowly as the large plate does, but the forward movement adds still another element of support that the sinking plate does not have, viz., the same mechanical law that causes a given surface in the air to sustain more as an aeroplane gliding forward at an angle than it would parachuting perpendicularly, the explanation being that, under the surface when parachuting, the inverted pyramid of air, once set in downward motion, offers no further resistance; whereas under the same surface gliding forward as an aeroplane the inverted pyramid of air is constantly changing.

Comparing a *Mauretania* hydroplane 88 feet wide with a hydroplane 4 feet wide, the cubical contents of the inverted pyramid of water displaced by the *Mauretania* would be, roughly, 47,000 times that of the small boat; and, curiously enough, the weight of the *Mauretania* is 45,000 tons, and a 26-foot hydroplane, loaded, about 1 ton. However, the *Mauretania* has an additional advantage. Referring to Fig. 2, showing a cross-sectional diagram of a *Mauretania* hydroplane between the centre and stern, the draught of 10 feet at each side would add 5 pounds pressure per square inch of water to the resistance of the pyramid beneath. Hence it would seem that the problem is not one of getting the vessel to "plane," but of so designing it that it will plane at the proper depth at maximum speed.

The Fauber vessel combines the principles of a hydroplane with an ordinary displacement boat, its design being based on the theory that, up to certain speeds, a load can be carried by displacement at less expenditure of power than by "hydroplaning"; and, therefore, at medium and maximum speeds the load is advantageously sustained, in part by displacement and partly by the action of the hydroplanes upon the water.

The hydroplane, as ordinarily known, consists of flat surfaces slightly inclined in the direction of movement. The principal disadvantages arraigned against these are (1) insufficient stability, (2) at high speed

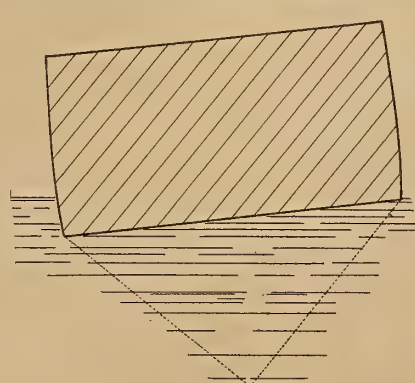


FIG. 3.—FLAT-BOTTOM HYDROPLANE

they strike the water so brutally that it is difficult to build a good sea boat, (3) a flat bottom does not make a suitable "berth" or pathway through rough water, (4) they are liable to pound and "see-saw," even in smooth water, and (5) a flat bottom does not have strength and will not cut into and resist violent seas.

A flat-bottom hydroplane has poor stability, for the reason as shown in Fig. 3—the surface rests on a pyramid of water, and when it tips or rolls to one side the only force to right it is the slight displacement it has on account of being lifted partly out of the water; whereas in the Fauber hydroplane, Fig. 4, representing a diagrammatic cross section, a new element, which may be called "hydroplane stability," is introduced, which acts instantly to right the boat.

Referring to Fig. 4 again it will be noted that, when the boat is tipped to one side, as shown, the concave surface on the low side acts more directly and with greater lifting power than the concave surface of the high side, which has only an angular and, in cases, a partial contact with the water; hence there are in the Fauber hydroplane two forces ensuring stability—viz., the one just described and also the displacement.

The "V" form of hydroplane surfaces, as adopted by M. Fauber, further prove to be the most practical shape beneath the bow of the boat to prevent pounding in heavy seas, the

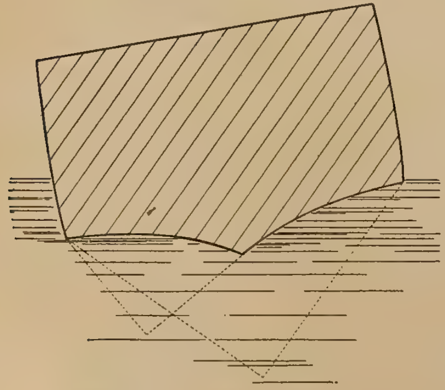


FIG. 4.—THE FAUBER HYDROPLANE

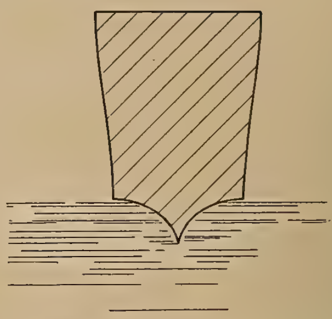


FIG. 5.—THE V FORM OF HYDROPLANE TO PREVENT POUNDING

apex of the "V" (Fig. 5) acting as a wedge, which enters the water without shock. Again, the "V" construction is particularly adapted to rough water, because it creates a "berth" or pathway on gradual, easy lines, which widens and deepens towards the stern, and, in combination with the pointed bow, the requirements of a swift, good, sea-going vessel is met in a very practical manner.

In hydroplane ships of large size the friction of the great surfaces in contact with the water and the longitudinal angle of these surfaces would have a tendency to give the water a forward movement, which, to some extent, would lessen the lifting power of the hydroplanes.

To avoid this action, and to get away from the difficulty caused by the racing of stern propellers, M. Fauber proposes to place a number of propellers beneath the hydroplane surfaces, dividing the motive power into six or eight units operating as many propellers. The action of the propellers jets the water backwards beneath the hydroplane surfaces, which counteracts the forward movement above described. In this arrangement of propellers the shafts would have about the same longitudinal angle as the hydroplanes, so that there would be no unnecessary waste of power. The keel line may project lower than the propellers, so that they are in a fairly well-protected position. It is a curious fact that Ramus, in his early studies, pro-

pounded this same idea of using several propellers underneath the boat.

A new and interesting feature of considerable importance, particularly in war vessels, is the possibility of disposing invisibly of the smoke from the funnels. The action of the hydroplane surfaces on the water creates a partial vacuum beneath each surface and behind the step of the preceding one, this air suction being caused by the friction and commotion of the water drawing the air in at the point of contact with the surfaces. In this feature exists one of the reasons why hydroplanes are more speedy and require less power than ordinary boats.

This stratum of air acts much the same as oil in a bearing. Air being 800 times lighter than water, it neutralizes the frictional contact between the water and the inclined surfaces, preventing, to a considerable extent, the drag or rolling action of the water which absorbs so much power.

In smaller vessels, M. Fauber has found, by repeated experiments, that if this vacuum is not relieved by an adequate supply of air, the actual thrust on the propeller measured by a dynamometer increases about 20 per cent. In ships this difference would probably be much greater.

By providing suitable connections between the air pipes leading to the hydroplanes and the smoke stacks of the boilers the smoke may be drawn down underneath the hydroplanes, where the gases would be quickly cooled and carried away by the water.

In building a large hydroplane ship, the proportions of width and height would probably be changed—the width increased and the height reduced, to provide the same margin of stability when the vessel "planes" at full speed, and it would have a draught of one-half to one-third the present draught.

FIG. 6.—HYDROPLANE RACING BOAT, THE RICOCHET

The great advantages of the hydroplane are not only the reduction of draught and displacement of water, but the hydroplanes reduce considerably the amount of frictional surface in contact with the water, as well as minimizing the loss by friction of that portion of the surfaces actually in contact, as previously explained.

We are all sceptical as to the practical utility of an invention, be it ever so plausible in theory; but our inventor has already obtained some really astonishing results with vessels actually built on these lines. It is

FIG. 7.—THE FAUBER HYDROPLANE TRAVELING AT 34 MILES AN HOUR

true these are only small boats; but, unlike the usual type of hydroplane, they conform more to the ordinary shape of a boat above water, and are capable of comfortably seating several persons. In the vessel illustrated a speed of 34 miles an hour was attained with six passengers on board, and with a lower number of passengers in a speed test no less than 37½ miles an hour was recorded, and this with a horse-power of only 60. Independent observers who have ridden in this boat speak emphatically of its extremely steady running at its highest speed.

Based on his experience with smaller vessels, M. Fauber has designed, *inter alia,* a hydroplane motor torpedo boat, which he estimates will be capable of a speed of 74 kilometres (40 knots) an hour. This is more in the nature of a torpedo launch, and is intended for carrying on the decks of cruisers or other war vessels, as has been advocated recently in connection with high-powered, fast motor torpedo launches of the Yarrow-Napier type.

It is 15 metres (49 feet) in length, and has a width of 2 metres 75, and a weight of 3½ tons, fuel and war equipment not included. The hull may be constructed entirely of steel, or a combination of steel and wood, which could be used to advantage in these small boats. The bottom, which constitutes the hydroplane surfaces, may be painted; but by preference is sheathed with manganese bronze, which gives a fine anti-fouling friction surface.

The motor equipment is of 350 to 400 horse-power, driving twin screws.

THE GASIFICATION OF PEAT

WITH RECOVERY OF CHEMICAL BY-PRODUCTS

By Charles A. Davis

One of the most effective methods of reducing wastes of natural resources lies in the utilization of low grades of fuel. Another important method is found in the isolation of by-products formerly thrown away, but thus made available for the market. When both of these results are secured at once, a great step in advance is secured.

In the present article, presented before the American Peat Society by Mr. Charles A. Davis, peat expert of the technologic branch of the United States Geological Survey, and published in this magazine by especial permission of the director of the Geological Survey, the latest developments of this important work are given, showing how, from one of the lowest grades of fuel, it is possible to obtain gas for power and heating, as well as a high-grade coke and sufficient by-products to pay for the entire cost of the operation.—The Editor.

BEFORE entering upon the discussion of the subject, it seems important to consider whether we are dealing with an entirely new and strange proposition in thinking of peat as a source of gas, or if it is not new, it will be greatly to our profit to learn how much experimental or commercial work has been done by those who have already tried the substance for gas production and what they have accomplished.

That this is no new question is at once apparent when any good work on peat industries is consulted; for it appears that as early as 1786 Thillage-Platel and Lebon coked peat in retorts to obtain tar and gas, and although they had little success, since their time there has been almost continuous experimentation in various parts of Europe, and even America has not been exempt from work of the same kind.

The middle of the nineteenth century was a period of great awakening to the possibilities of chemical industries, and it is not surprising that at that time peat should come into prominence as a basal material from which to derive gas and other substances. As a matter of fact, there were a considerable number of places in Europe where, for a time, peat was used as a source of illuminating gas, but chiefly on an experimental basis; and as coal was more easily handled and could be had in abundance, it sooner or later was given the preference. Its use was not abandoned, however, before it was thoroughly proven that peat would make good and cheap illuminating gas when distilled in properly constructed retorts, and especially when enriched by the addition of gases obtained by fractioning some of the tarry distillates.

Not only were these facts demonstrated to the satisfaction of the chemists of the time, but investigation was carried so far and with such enthusiasm that in Great Britain two large plants were established for coking peat and recovering, by redistillation, the chemical by-products known to be obtainable from the condensed gases driven off during the coking process.

These plants were located at Dartmoor, in England, and at Kilberry, near Athy, County Kildare, Ireland; but neither of these experiments were commercially successful, apparently largely because of poor management and the desire to make the showy products, such as paraffin and aniline, which were costly to make and not correspondingly salable. The balance sheets published by these concerns show large profits as the result of their operations; but their permanent suspension, after short experimental runs, seems to indicate that the anticipations were not realized.

As a further indication of the state of the knowledge of this period

under discussion, it may be said that Professor Brande, in 1851, read a paper before the Royal Institution of London, in which he outlines the various products to be obtained by the destructive distillation of peat as follows:

1 Sulphate of ammonia; (2) acetate of lime; (3) pyroxylic spirit (wood or methyl alcohol); (4) naphtha (or light petroleum oils); (5) heavy oils (illuminating and lubricating oils); (6) paraffin, or white mineral wax. Present-day chemists would add but two more substances which now have a market value, asphaltum and creosote oil.

Even before the data mentioned other writers in various parts of Europe had made similar statements, so that it is no new matter that is before us for discussion, so far as the primary facts are concerned. Indeed, Leavitt, in an early edition of "Facts About Peat," reports that "a gentleman connected with one of the large manufacturing establishments in Utica, N. Y., wrote him in 1865 that he had obtained 612 cubic feet of illuminating gas from 160 pounds of condensed (machine) peat," and that at Portland, Me., at an earlier date gas enough was made from peat to light the entire city for "one or two evenings with highly satisfactory results."

With the increase in chemical knowledge, and especially with the tremendous advances made in applied chemistry during the past twenty years, there has come a constantly increasing demand for the chemical products that can be made from organic matter by subjecting it to distillation or gasification. During the same time the science of chemical engineering has grown up so that it is now possible to manufacture chemical products at a profit that formerly could only be made on an experimental basis. Hence the question of peat gasification and the manufacture of by-products recoverable from the process takes on new interest, and is well worth our close attention.

The matter has still greater interest because there have been at least three different processes brought out in European countries within the past eight or ten years which seem well within the limits of commercial possibility, and as each of these is now embodied in one or more large plants that have been operated for a time, it is evident that success is within sight, if not already achieved.

Moreover, peat is now gasified with entire success in a steadily growing number of places in Sweden and Germany in gas producers for power and fuel purposes, and this phase of the problem is of great economic importance to all who own peat deposits.

METHODS OF GASIFYING PEAT

The chemical composition of peat does not differ greatly from that of wood and coal, viz., it is a mixture of highly complex chemical substances made up of definite proportions of carbon, a solid element, and of hydrogen and oxygen, both gases at ordinary temperatures, combined in fixed quantities.

In the peat are compounds containing small and variable amounts of the gaseous element nitrogen, which form some of the most valuable constituents, since they may be converted into ammonia compounds on heating.

The elements are so arranged in the compounds in which they exist in peat that they can be quite readily disassociated by the action of heat and recombined into new and simpler compounds — some of which are solids, some liquids, and still others are gases—at the usual temperatures of the air. It should also be noted that most of these compounds are capable of chemically uniting with the oxygen of the air when their temperature is raised enough, and during the process of taking up ogygen heat enough is developed to convert many of them into gases which take fire. The results of the changes are the formation of two very simple and permanent compounds, carbon di-

oxide or carbonic acid, a heavy, colorless, inert gas, and hydrogen oxide or water, which exists at high temperatures as steam, a gas, at usual atmospheric temperatures as a liquid and at low temperatures is converted into the well-known solid, ice.

When any hydro-carbon fuel is burned the flame is produced by the union of oxygen with gaseous and liquid compounds that have been formed by the heat developed in that part of the fuel already afire. The carbon of the fuel gradually becomes more and more nearly pure, as the heat drives off the flame-producing tarry and gaseous hydrogen compounds, and is the last to be consumed, remaining as coke or charcoal, which burns with nearly colorless flames and intense heat as it is attacked by the greedy oxygen.

This is what happens when what is called "combustion" takes place in fires in ordinary combustion chambers well supplied with air, the heat of the chemical action being sufficient to maintain the fire after it is once started. In such combustion, however, heat energy is all that is obtained aside from the useless products of combustion already mentioned, and which are generally turned out into the air through the chimneys of the furnaces.

If the fuel is to be decomposed by heat, and any or all of the products of decomposition obtained as usable substances, it is evident that the air must be excluded both from the place where the heated fuel is being tested and from the products until they are so cool that the oxygen will no longer attack and further decompose or burn them. This has been accomplished in various ways, according to the kind of product which was sought, although, in fact, the principle is substantially the same in all.

The simplest and least efficient process is the one used for making charcoal or coke for fuel, in which the peat is piled in heaps and covered with a layer of earth, after which the fuel is set on fire and burned with just enough air to generate heat sufficient to drive off the volatile matters without burning the carbon in more than a small portion of the stacked fuel. The coke or charcoal alone is saved, the volatile matters all escaping as vapours and smoke.

The first improvement made on this process was to utilize the heat of the burning gases to drive off the volatiles from the carbon by setting fire to a mass of the peat in an upright iron furnace, to which fresh material could be added from time to time until the entire furnace was filled with blazing peat. As soon as this was done the air was shut off at the top and bottom of the furnace until the fire burned itself out. This method was wasteful in theory and practice, and only the coke was saved, amounting approximately to a third of the weight of the original material or less.

In the processes lately devised for producing coke and charcoal from peat, however, retorts have been used exclusively. This method consists of heating the fuel to be coked in closed, air-tight iron receptacles placed either horizontally or vertically, so that they could be heated entirely from the outside. It is evident that, by such an arrangement, the volatile matters can be conducted away from the retort without ignition, cooled and condensed, and used in any way desired, while the coke or charcoal also may be handled and cooled without loss by blazing up.

In such developments the objects sought are the coke, the gas, or both. In the first case the heating is carried on until all of the volatile matter is driven off, and, in the second, until no more gas of good quality comes off from the retorts. In either case there is a considerable amount of liquid, watery and tarry matter, obtained by the condensation of these classes of compounds in the apparatus for cooling and washing the gases.

More recent than any other is the

development of processes of converting all of the fuel elements into gas in special forms of furnaces called gas producers, or sometimes "Dowson" producers, from the English inventor of this type of gas generators. In these generators all of the fuel is gasified by intensely heating it with a limited supply of air. The gases obtained are of low illuminating and thermal value, but when exploded in the cylinders of gas engines or burned with proper burners, are good sources of power or make satisfactory fuel. The use of producer gas has rapidly increased within the past decade, since it permits the use of the cheapest and poorest grades of fuels, because of the high percentage of efficiency obtained by the use of the gas in suitably constructed engines.

It has been stated that in the gas producer all of the fuel elements are converted into permanent gases. This is in theory only, for in practice it is found that a certain amount of liquid products pass through the fuel bed and have to be removed before the gas can be satisfactorily used; but the amount of such materials is relatively small, and in the most recently contructed types of producers is reduced to a minimum.

In principle, the gas producer is a furnace constructed so that a very deep fuel bed can be constantly maintained and kept at a high temperature. The fuel at the bottom is kept supplied with all the air necessary to completely oxidize it. This produces intense heat, and as the gases are formed they are drawn by exhaust fans or by the piston strokes of a gas engine through the highly heated fuel bed, where a part of their oxygen is taken from them by the hot carbon and hydrogen molecules of the fuel. Thus when they reach the top of the furnace they have been changed in composition, and are again capable of taking up oxygen—that is, of burning. To illustrate, a molecule of carbon dioxid formed at the bottom of the fire will be changed to carbon monoxid as it passes through the fuel bed, because some white-hot atom of carbon with which it comes in contact will seize one of the two oxygen atoms present in it and unite with it, with the result that there will be two molecules of carbon monoxid instead of an atom of carbon and one molecule of carbon dioxid. In the same way the steam formed by the oxidation of the hydrogen of the fuel is decomposed with the formation of free hydrogen, while its oxygen is united with carbon to form carbon monoxid, and both pass from the gas producer as free gases.

To recapitulate, we may have three purposes in gasifying peat:

(1) To drive off the volatile matters to get coke or charcoal.

(2) To drive off the volatile matters to get illuminating gases.

(3) To convert all of the fuel into low-grade fuel gases.

In the first case, the substances of commercial value that may be obtained besides coke are tar, tar water or gas water, and heavy tars; while from the gas producer the waste is chiefly gaseous or in the form of ash of small value.

Of these materials the liquids may be either wasted or may be used, after proper treatment, to supply in part the large commercial demand for the chemical substances that can be derived from them, while the coke and the gas have good fuel value and are in themselves so desirable that they are sought at the considerable expense of production.

The processes of obtaining the salable substances from the waste liquids are simple, and are such as are used in all chemical plants, namely, stills, evaporation tanks and crystallizing vats; hence they need no special description here.

Moreover, in the best installations yet made they are so planned that the fuel gases are conducted from the coking retorts to the furnaces, where they are burned to furnish the heat necessary to do the coking, run the engines and perform all of the work about the plant. In addition,

the heated spent gases, instead of being allowed to carry the heat of combustion into the air, are used to dry the peat and perform a part of the coking and much of the distilling and evaporation; hence economy of fuel is attained in a high degree.

The best example of a process for making peat into coke and charcoal, and which has been planned and operated on a commercial scale for the recovery of by-products from the condensed gases, is that invented and developed by Dr. Martin Ziegler, of Germany, with which many engineers are already familiar. The peat is coked in vertical fire-brick and cast-iron retorts connected with condensers for cooling and saving the liquid distillates from the retorts. The apparatus is so arranged that the heat of the waste gases from the furnaces is used to heat the retorts and concentrate the solutions of the by-products, while the non-condensed gases from the retorts, after they have passed through the condensers, are turned back to the furnaces to carry on the coking operations. It is thus evident that the process, after once being started, is self-maintaining.

By the Ziegler process a high grade of peat coke, similar in quality and value to good hardwood charcoal and excellent for metal-melting and refining, is the primary product. From the tar may be obtained by distillation

	Pounds per 100 of Dry Tar.
Light petroleum oils	12
Heavy petroleum oils	25
Lubricating oil	15
Paraffin wax	2
Asphalt	16
Creosote	10
Gas and loss	23

From the tar water may be obtained

	Per 100 Pounds of Tar Water.	Per Ton Dry Peat Substance.
Acetic acid	1.58	12.640
Methyl alcohol	0.764	6.112
Ammonia	0.086	0.688 = 5.261 $(NH_4)_2SO_4$
Organic acid	0.207	6.656

The figures given for a ton of peat treated by this process, according to an official report, are as follows:

The peat delivered at the kiln costs $1.19 per long ton, or what is almost the same per metric ton. On coking it yields:

Substances.	Amount in Pounds.	Value in U. S. Currency.
Peat coke	777.6	$3.75
Tar	86.2	.52
Wood alcohol	13.2	1.00
Lime acetate	13.2	.17
Ammonium sulphate	8.8	.21
		$5.65

Gas in an amount greater than required to dry and coke the peat and worth at least 25 per cent. of the value of the coke is produced.

Figures derived from the manufacturer's agent in America for this process show that a four-oven plant treats about 100 tons of air-dried peat each twenty-four hours, and from this the following quantities of by-products would be obtained:

900 lbs. ammonium sulphate	$3.07 per 100 lbs.	$27.63
1,320 lbs. acetate of lime	2.35 per 100 lbs.	31.02
65 gals. methyl alcohol	.70 per gal.	45.50
280 gals. light oils	.07½ per gal.	21.00
95 gals. heavy oil	.07½ per gal.	7.12
715 lbs. paraffin	.03¾ per lb.	26.81
3,100 lbs. creosote oil or carbolic acid	.02¼ per lb.	69.75
440 lbs. asphalt	.005 per lb.	2.20
		$231.03
Deducting 10% for sale expenses		23.03
Actual value of by-products		$208.00

In addition, 33 tons of peat coke would be obtained.

The total expenses per day, including wages and salaries, chemical supplies, cost of preparing the peat, interest and depreciation, and general incidental expenses, are figured at $308.50, so that the 33 tons of coke cost $100.50, or $3.05 per ton.

If the plant is increased to three times the given capacity the quantity of by-products is increased by so much, while the total cost of production is not increased in proportion, so that the by-products nearly or quite pay all expenses, leaving the coke as practically all profit.

The cost of such a plant is large, however, and but three have, so far, been constructed in Europe. The estimates given for the smaller plant of four ovens are $160,000, including a working capital of $60,000.

The financial success of such a

plant depends largely upon the skill with which it is managed and upon finding a good market for all of the by-products, which, it will be noted, are staple products. In Ziegler's most improved plant the tar is converted directly into a lubricating material resembling soap, which is more profitable than extracting the oils, as these come into competition with the cheap petroleum derivatives and can hardly be produced with profit in the United States.

The reports as to the operation of the three plants in Europe designed by Dr. Ziegler are somewhat conflicting; but, on the whole, they seem to be profitable, although not to the degree anticipated by the inventor and his backers, as is sometimes the case with new enterprises.

Later than the development of the coking of peat and by-products recovery from the retorts came that of the producer gas plant. At first there was no attempt to do more than purify the gas generated of impurities, such as tar and ashes, by passing the gas through scrubbers, which are, in effect, filters and settling tanks. In this stage coke, anthracite and charcoal were the fuels used as the source of gas, and but little waste material was to be had from them at best, so that no attempt to recover by-products was necessary.

As the use of the gas producer spread to other fuels, especially to bituminous coal and peat, the proportion of condensible gases given off was much greater, and among them the valuable ammonia. Recently, therefore, we have heard much of by-products recovery by the addition of suitable apparatus to the typical gas producer to fix in permanent form and save the combined nitrogen of the fuel, which the heat converts into ammonia and drives off with other gases.

The demand for compounds of ammonia for agricultural fertilizers and as sources of ammonia gas for refrigeration has so greatly increased during the past few years that new sources of this valuable and comparatively costly material are constantly being sought; and it was as long ago as 1889 that Dr. Ludwig Mond, in a presidential address before the English Society of Chemical Industry, presented a statement that experiments in distilling coal in a current of steam had given him almost twice as much ammonia as he had obtained by distilling the same coal in a current of air and steam. The studies by Mond led to the development of the type of gas producer bearing his name, and especially designed for the development of power gas from coal with the recovery of the largest amount of ammonia possible. A brief account of the operation of this producer may not be out of place here. The producer itself is a vertical cylinder, with double iron shell, and tapering out into a cone-shaped base, which passes to an ash pit sealed with water at the bottom. The lower two-thirds of the cylinder and the cone are lined with thin fire-brick, while above the lining are the outlet pipes and the hopper for introducing fresh fuel, which is gas and air-tight.

The hopper opens downward into a wide cylinder, which reaches to the level of the fuel bed, and has its mouth some distance below the opening of the outlet pipe. The latter is connected with a series of double iron tubes, which serve as regenerators for pre-heating the air and steam used in the producer and at the same time cool the gases passing through into the recovery plant. After leaving the regenerator the gas is forced into a tar-extraction chamber and then to the ammonia tower, which is filled with brick checker work, kept constantly wet with dilute sulphuric acid sprayed into the tower through pipes at the top.

The ammonia in the gas, in passing through the checker work in the tower, is brought into close contact with the sulphuric acid and forms

ammonium sulphate, which flows out from the bottom of the tower into a properly placed tank, from which it is pumped to the top of the tower again, to go through the process again until the solution has about 36 per cent. of the salt. The ammonium sulphate is then pumped to concentrating tanks, purified, concentrated and crystallized, just as any salt would be.

The fuel in the prolongation hopper is heated as it slowly passes down towards the fuel bed, and the water and some of the tars are distilled off. As they cannot escape into the hopper, they are forced into the hot fuel bed, where they are decomposed into permanent gases. The fuel is kept at a dull red heat, being prevented from getting hotter by the large amount of superheated steam which is mixed with the air; 2½ pounds of steam and 3 pounds of air at about 485 degrees F. are furnished for each pound of fuel used. Only about one-sixth of the steam is decomposed, the rest being condensed in the scrubbers. The object of the excess of steam is to keep the temperature so uniformly low that the ammonia will not be decomposed, and also that the ash will not get heated enough to fuse and form clinkers. The gas leaves the producer heated to about 925-930 degrees F., and then takes the course already described.

The Mond producers were primarily designed for the use of coal and for installations of large size. As much as 4 tons of ammonia sulphate have been obtained from 125 tons of coal, although the yield of the by-product must obviously be controlled bv the per cent. of nitrogen in the fuel. The theory of this producer lends itself most evidently to the use of peat as a fuel.

More recently than the use of bituminous coal in power gas producers in Europe has come the use of peat, and it is only a short time ago (less than two years, in fact) that reports began to be given out by Caro and Frank, of Charlottenberg, Germany, relative to the successful gasification of peat in special producers, accompanied by the recovery of ammonia in large quantities—nearly up to the theoretical amount possibly obtainable from the combined nitrogen shown by analysis to be present in the peat.

The detailed descriptions of the new processes showed them to be primarily based on Mond's experiments and adaptations of his type of producer, since the distillation is carried on in a mixture of air and an excess of superheated steam. This gives low temperatures, which are essential to the formation of the maximum amount of ammonia, since the gas is decomposed into nitrogen and hydrogen at temperatures above a dark-red heat; hence in ordinary producers but a small fraction of the ammonia possible can be recovered, as it is decomposed as fast as formed.

It may be easily shown that the amount of ammonium sulphate that could be obtained from peat with a given percentage of combined nitrogen is $132 \div 28$, or $33 \div 7$ times the number of pounds of nitrogen known to be present; it is, therefore, easy to calculate the maximum amount obtainable under theoretical conditions from any sample of peat which has been properly analyzed. A short ton of peat, theoretically dry, with 1 per cent. of nitrogen, should yield 94 pounds of ammonium sulphate, and one with 2 per cent. nitrogen, 188 pounds, which, at current prices for the product of about $60 per ton at the works, makes it worth while to consider the recovery of the material, especially as the gas which has been freed from it is better for power purposes after it has been taken out.

Another advantage claimed for the Caro and Frank adaptation of the Mond producer is that peat containing 40 or even 50 per cent. of water can be used, and this without other preparation than plowing it up and drying it on the surface of the bog. Actual tests made and announced by

the inventors do not show quite the theoretical amount of ammonium sulphate; but an average of 107 pounds of ammonium sulphate per ton was reported from an experimental run on 715 tons of peat from Italy gasified in a Mond producer, the dry peat originally having 1.62 per cent. of nitrogen.

Aside from the ammonium sulphate, there were obtained as the principal product 48,087 cubic feet of gas, which had a calorific value of 152 B. T. U. per cubic foot, and which was used in generating the steam used in the gas producer and in evaporating the ammonium sulphate solution, leaving gas enough to generate in gas engines 480 horse-power-hours for each ton of water free peat gasified. The cost of production per 100 tons of dry peat used is estimated at $125, including all charges, while the ammonium sulphate produced was worth at the market price $325, and the gas was free and reached the engines perfectly pure.

The Frank and Caro process is not the only one that has been developed in Europe for recovery of ammonia compounds in connection with power gas production from peat. Dr. Ziegler, who designed the coking plants mentioned, has invented a special form of gas producer, which is designed for recovering by-products. This type is reported in successful operation at Schelecken, Germany; but on account of its small size the recovery plant failed to be commercially profitable. Crossley Brothers, Ltd., of England, have placed a similar gas producer on the market for using peat and recovering ammonium sulphate.

From this brief discussion it is apparent: (1) That this phase of peat utilization is much farther advanced in Europe than in the United States, where no manufacturer has yet advertised a gas producer that he will guarantee to use peat for fuel, to say nothing of even contemplating the recovery of any by-products, apparently dismissing the latter proposition off-hand as impractical, if not impossible.

(2) That for small gas producer plants for generating electricity or other power the amount of ammonium sulphate to be obtained even from peat rich in nitrogen, while technically entirely possible, would probably not prove commercially successful, since the cost of maintaining a small recovery plant is high when compared with the margin of profit. This is due to the fact that the same technical superintendent and high-priced workmen are needed in the small as in the large plants. On the other hand, peat that is rich in nitrogen, gasified in a gas producer, will yield considerable ammonium sulphate, if properly treated, and the commercial limitations can only be determined by actual experiment.

A large plant embodying these principles is being erected in Italy, another in Germany, and still another is planned for England, the latter having a proposed capacity of 65,000 tons of theoretically dry peat a year. As the peat to be used here has an average of 1.6 per cent. of combined nitrogen, and the efficiency of the process is about 60 per cent. of the possible production of ammonium sulphate, there will be an output of some 3,000 tons of this product besides the gas. It is expected that the latter product will furnish, through the use of gas engines of the explosive type, 5,000 kilowatts. The gas engines will be in the smaller sizes, and it is estimated that, with these, 22.5 per cent. of the theoretical heating value of the fuel will be obtainable as an electric power, and that the consumption of heat having a thermal value of 8,600 B. T. U. per pound will be almost 2 pounds for a commercial electric horse-power per hour. These independent figures are so closely in accord with others from entirely different sources that they may be depended upon, and it is possible to see how power that has a unit cost of less than two-tenths of

a cent for a unit is to be attained, even where the cost of the fuel is rated at $2 per ton, which, with every item accounted for, is very high for peat fuel at the bog, where it ought to be had for a dollar or less.

From this brief discussion it is apparent that commercial power gas from peat is more than a possibility to be thought of in the remote future. It is actually an accomplished fact in Europe, and with its development has come another, which in itself is a source of profit—the successful manufacture of ammonium sulphate from the gas as a by-product.

Let us now turn our attention to the Woltereck process of obtaining ammonium sulphate from peat combustion. Before turning to this, however, it may be well to note that, besides the processes mentioned for the recovery of ammonia from gases distilled from peat, Hoering and Mjoen have patented a furnace for making use of the water evaporated from the peat, so that it reacts to increase the amount of ammonia and tar recoverable. Ireland and Lugden have also patented, in England, a method for preparing ammonia from the nitrogen of the air by leading air and water vapour through peat heated to a temperature of from 575 to 950 degrees F. (300-500 C.) in upright iron retorts covered with fire-brick. These processes have not been reported upon, so it is assumed they have not attracted capital enough to be established on a large scale.

The Woltereck method of production of ammonia differs from any that has been described, in that the inventor claims that he gets the nitrogen for the ammonia produced directly from the air, and not from the peat. His paper has already been read and discussed at the meeting this afternoon, but from the scientific aspect of the question and not its practical one. The claim is made in this paper, backed by reports of experiments that apparently have been worked out with great care, that when wet peat is burned at a temperature barely sufficient to keep the fire going in a specially constructed furnace, some of the nitrogen of the moist air forced into the combustion zone unites with the hydrogen of the organic matter that is being decomposed and forms ammonia. In addition to the ammonia as the result of the wet combustion tar, tar water and other distillates are obtained in abundance, and from these acetic acid, in the form of calcium acetate and paraffin, are manufactured. There are no valuable permanent combustible gases obtained as the result of these operations, as all of the carbon of the peat is converted into carbon dioxid.

The actual operation of the plant at Carnlough, Ireland, is described by the pamphlet issued by the Chemicals Proprietary Company, Ltd., as follows:

After the peat has been dug and conveyed to the works, it is automatically fed into hoppers worked with compressed air and quickly dropped into the furnaces. Here it is subjected to moist combustion by means of a blast of air charged with water vapour at a carefully regulated temperature of 750 to 950 degrees F. (400 to 500 degrees C.). The resulting gases contain paraffin tars, acetic soda and ammonia. The tars are removed by the Woltereck scrubber, which retains all tarry matter without causing any condensation and consequent loss of ammonia. (The tars are extracted from the gases by passing them through a bath of heavy petroleum oil heated to about 575 degrees F.—300 degrees C.) The acetic acid is next absorbed in the alkali tower, where the gases meet a hot solution of soda or milk of lime, $Ca\ (OH)_2$ and combine with it to form acetate of soda or of lime, which may afterwards be treated for the recovery of acetic acid or the production of acetone.

The gases pass from the alkali tower to the acid towers, where they meet a stream of hot sulphuric acid, which combines with the ammonia to

form sulphate of ammonia, the chief object of the process. After the acid is completely neutralized the solution of ammonium sulphate is drawn off to the crystallizing vats. The solution of the sulphate is there further concentrated by evaporation and allowed to crystallize, and, after centrifuging to remove any adhering liquor, is ready for shipment. The paraffin tar is drawn off from the scrubber, when a sample of the oil therein solidifies on cooling. It is then subjected to distillation, to remove the lighter oils, and a crude paraffin wax, worth about $25 per ton, remains, without further purification. The acetate solution obtained from the alkali tower is evaporated to dryness and distilled with sulphuric or hydrochloric acid to obtain acetic acid, or can be subjected to dry distillation to produce acetone.

This, of course, is the best presentation that can be made of the process as a whole, and gives no details of the many mechanical and other difficulties that have been met in the construction of the furnace, the grates, the tar scrubber, in fact every detail of the great plant that is reported in process of development in Ireland, and which has an estimated annual output of 5,000 tons of ammonium sulphate. When it is noted that Woltereck claims a minimum of 5 tons of ammonium sulphate for each 100 tons of theoretically dry peat treated, and uses peat containing up to 75 per cent. of water, it becomes evident that enormous quantities of raw material are to be handled, as an easy calculation shows that, with a minimum production of the chief product, 10,000,000 tons of peat with 75 per cent. water must be dug and handled per year, or the entire quantity of peat that would be present in a bog two square miles in area and 10 feet deep. There are few bogs in the United States on which it would pay to install the half-million-dollar plant now approaching completion at Carnlough.

At the present writing there is going on in the Journal of the German Peat Society, "Mitteilungen," "Verein zur Foerderung der Moor-Kultur im Deutschen Reiche," an animated discussion between Dr. Caro, one of the inventors of the Caro and Frank method of by-product recovery from peat gasification in the Mond gas producer, and Dr. Woltereck, who read a paper before the society on his process during the winter. Caro insists that Woltereck is wrong in his statement that he converts some of the nitrogen of the air into ammonia by his process, and that the amount of ammonium sulphate that he reports shows that this is so, because the amount obtained reduced to percentages is what would be expected from the amount of nitrogen shown by analysis. This, he states, will not pay for recovering, neither will the paraffin and acetic acid which can be saved. Woltereck replies sharply that Caro does not know what he is talking about, and makes an attack on the process in which Caro himself is interested, pointing out that his own process (1) gives a much larger recovery on ammonium sulphate than Caro's (which he points out is really stolen from Mond).

(2) Permits the use of peat with 85 to 80 per cent. of water, as compared with that with only 45 to 50 per cent.

(3) Is independent of all other industries, so that the plant can be operated on its own merits, and not be founded on an entirely foreign business, from which at times no profit can be won.

(4) Acetic acid and paraffin enough can be recovered to cover all expenses of digging the peat and burning it, so that the ammonium sulphate, worth about $60 per ton, becomes practically clear profit.

There the matter rests, with the other side yet to be heard from, and there also we must leave it, until by repeating the tests described by Woltereck and checking up his re-

sults, or by the actual erection of an experimental plant, actual demonstration of the value of one process or the other can be had. Personally, the writer can see much that is good in each of these methods of treating peat. If power is sought and can be sold in large quantities at a profit, the Caro-Frank producer, with recovery of ammonium sulphate, certainly is a good commercial proposition, as the gas has to be scrubbed anyway, and the demand for the ammonia salt is almost unlimited and will increase as time goes on.

On the other hand, Woltereck's process is one which makes the production of certain chemical substances its sole aim, and is to be considered as an attempt to establish a new source of ammonia production, with the manufacture of acetic acid and paraffin as by-products. The energy stored up in the peat is all used up, so the author claims, in bringing about a chemical union between some of the nitrogen of the air and some of the hydrogen of the organic matter of the peat, as this is liberated by the heat combustion. That peat with a very high percentage of water can be used in this way makes the process most valuable, if all of the claims of the author are substantiated. Yet often the question will arise in the future whether the stored-up energy of the peat is best and most profitably employed in the production of power to give light, or manufacturing and transportation facilities, with a little material for increasing the world's food supply, or whether it shall be wholly used in the production of a larger amount of the fertilizer and no power obtained from it. These questions time and the immediate commercial needs of particular enterprise alone can decide.

From the facts and theories presented, it seems evident that the present standing of gas production from peat is that it has reached the commercial stage in Europe, and that producer gas from peat is used for power and fuel purposes in many places on an exceedingly profitable basis. It also seems that the recovery of a number of chemical by-products may be carried on by treating the condensable gases obtained in the course of the necessary purification of the power gas, and that the most valuable and easily obtained of these substances is ammonia, which is probably obtained in the largest possible proportions if treated as a by-product in the Mond type of gas producer, by low-temperature distillation, induced by large amounts of steam in the air used in keeping up the combustion. The recovery of ammonia, as well as other by-products, will be most successful in large installations.

The Woltereck process is not a by-products or peat gasifying process, but a method of manufacturing ammonia by burning peat under such conditions that no combustible gas or other product is obtainable.

In conclusion, it should be said that it is exceedingly desirable to have some of these processes tried under American conditions, and it is hoped before long that the members of the American Peat Society, or its largest and most important section—that of New York—will take hold of the question of erecting a peat products plant on such a basis that we can learn how far we are behind our European friends in all matters pertaining to peat utilization.

BELT CONVEYORS FOR HANDLING MATERIALS

By George Frederick Zimmer, A. M. Inst. C. E.

THE belt conveyor is a very popular means of conveying both heavy and light materials. When first introduced, about 1868, by Mr. A. G. Lyster, engineer to the Mersey Dock and Harbour Board, it was used for conveying cereals and seeds only, but between the years 1885 and 1890 a number of more or less experimental plants were erected for minerals, and the credit for this extension of the utility of band conveyors is principally due to Mr. Thomas Robins. At the present day thousands of installations are successfully at work, handling almost all kinds of material; hot and sticky substances being almost the only ones for which this method is unsuited.

The great advantages of belt conveyors are: the small driving power required to manipulate them, their noiseless and smooth working, their large capacity, and their comparative security against breakdowns. It goes, of course, without saying that these advantages obtain only where first-class conveyors are installed, in the construction of which all circumstances as to the nature of the material to be handled, the speed of travel, the number and size of the supports, the construction of the terminals, and the system of lubrication, have been carefully considered.

The general construction of a belt conveyor is well known. It consists of an endless belt running over two terminal drums, being, in addition, supported on its way by suitably arranged rollers at intervals.

An investigation of the details of construction, capacity, power consumed in driving, and other points upon which there exist some doubt or difference of opinion will be more to the point, and it is, therefore, the object of this article to confine itself to such items.

THE BELT.

The most important part of a belt conveyor is undoubtedly the belt. Stitched canvas or woven cotton belts are often used, particularly for small installations, on account of the comparatively small first cost. They are usually saturated with some oily substance, so as better to withstand the influence of the weather, but for first-class work of a permanent character there is nothing to equal a good india-rubber belt.

Rubber belts are composed of a foundation of cotton duck covered with rubber solution or "friction" pressed together, and the whole is then enclosed in a rubber covering. The belt thus produced is then stretched and finally vulcanized.

Exhaustive experiments have been made by Mr. Thos. Robins to ascertain the best class of rubber covering to use for conveyor belts. Pure rubber is, no doubt, the most serviceable material, as it is almost indestructible, and as the rubber suffers very little wear from contact, even with sharp and cutting materials, but as pure rubber is exceedingly costly, it is practically beyond the reach of ordinary users, and the experiments alluded to have been made to ascertain what kind of admixture to the rubber will deteriorate its wearing qualities least.

It is interesting to find from these tests that even steel wears faster than rubber under a heavy sandblast, and under conditions to which

a belt would be exposed when handling minerals. The following diagram and table shows the wear on the different materials subjected to a uniform sand-blast for 45 minutes:

DIAGRAM OF WEARING QUALITIES OF VARIOUS MATERIALS

A.	Rubber belt	1.0
B.	Rolled steel	1.5
C.	Cast iron	3.5
D.	Balata belt, including gum cover	5.0
E.	Woven cotton belt, high grade	6.5
F.	Stitched duck, high grade	8.0
G.	Woven cotton belt, low grade	9.0

The object of the rubber covering is two-fold. The thicker covering on the upper side is to resist abrasion, and the remainder of the cover is for the purpose of protecting the body of the belt from moisture. Since the rubber solution, forming the "friction" with which the duck is held together, is not absorbed sufficiently by the fibres of the cotton duck to make the body of the belt waterproof and, as the cotton where exposed absorbs moisture as readily as the wick of a lamp, it is most important that the outer covering should be perfect, particularly if the belt is exposed to the wet.

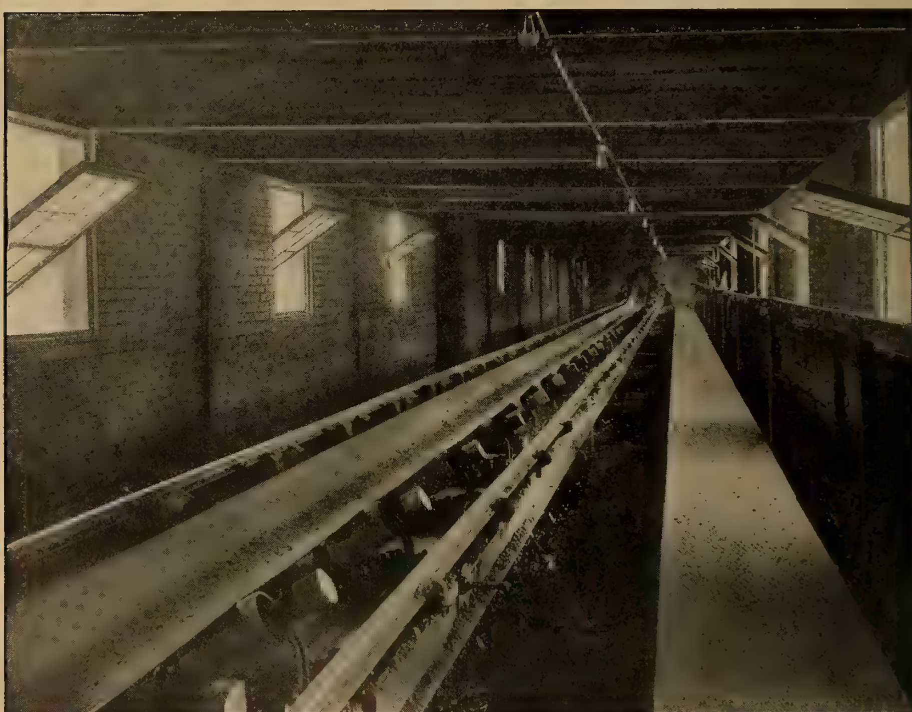
Any abrasion or cut in the covering sufficiently deep to admit the moisture to the cotton may cause serious damage to the belt, as the rubber loosens its hold on the damp cotton, forming blisters, which soon elongate along the belt, through the compression and extension of the inner parts when passing over the terminals.

BELT CONVEYOR DELIVERING CRUSHED STONE TO BINS. THE JEFFREY MANUFACTURING CO., COLUMBUS

The number of plies of duck of which the belt is composed must be such as to make the belt sufficiently rigid to support the maximum load between the supporting idlers without sagging. This is the only condition which need be observed for ordinary conveyors of medium lengths. According to Mr. C. K. Baldwin, of

Chicago, the number of plies should be as follows: belts of 12 to 14 inches wide should be not less than three-ply; belts, 16 to 20 inches wide, not less than four-ply; belts 22 to 28 inches, not less than five-ply; while not less than six-ply should be used for belts from 30 to 36 inches in width.

For extra long conveyors, however, and in cases where one or more additional belts or other machinery are to be driven from the end terminal of a conveyor, the tensile strength of the belt has to be taken into consideration, and the belt so constructed that the tension is not more than 20 to 25 pounds per inch per ply, although a good belt should have a breaking strain of about 400 pounds per ply per inch. The Robins type of belt is made with a flexible central portion by stopping off some of the plies of duck at varying distances from the edge and by substituting a thicker layer of india-rubber to make up for the missing duck. This not only makes the belt conform more readily to the troughing shape of the idlers, but the thicker layer of rubber also reduces the wear and tear which naturally comes in the middle of the belt, whilst the stiffer sides of the belt support the trough between the idlers and gives it the necessary tensile strength.



BELT CONVEYOR DELIVERING COAL INTO BINS AT PEORIA GAS & ELECTRIC CO. JEFFREY MFG. CO.

Some very interesting tests have been conducted by Mr. Edwin J. Haddock of Columbus, the results of which appear in the Proceedings of the American Society of Mechanican Engineers, as to the behaviour of conveyor belts under tension, more particularly to ascertain the effect of initial tension on the tractive force of conveyor belts on the driving drum.

The driving terminal used for the test consisted of a drum 42 inches

diameter, with the snubbing-idlers so arranged as to give a belt contact of 180 degrees, the tail terminal being so arranged as to exercise a variable tension in a horizontal direction by means of a rope running over a pulley to receive a weight.

The weights suspended were as shown on the following table, and the experiments were made in the order given:

TABLE No. 1.

SHOWING THE EFFECT OF DIFFERENT TENSIONS ON THE SAME TERMINAL OF A BELT CONVEYOR.

Tension Weight.	Initial Belt Tension.	Amperes.	Effective Pull on Belt.	Belt Strain. Maximum.	Belt Strain. Minimum.
650	325	14.0	260	455	195
800	400	16.5	330	565	235
1,300	650	24.0	550	925	375
1,500	750	29.0	690	1,095	405
2,000	1,000	38.0	650	1,475	525
1,500	750	31.0	750	1,125	375
1,250	625	25.0	575	913	337
1,000	500	22.0	490	745	255
750	375	18.0	370	560	190
3.000	1,500	56.0	1.450	2,225	775

Beginning with a weight of 650 pounds and gradually increasing to 1,500 pounds, the belt stretched but slightly, but under the additional 500 pounds, with a total of 2,000 pounds, the belt elongated about 3 feet in its total length of 158 feet. The belt then remained without further stretching whilst running under the weight. On removing the load gradually to 750 pounds, the belt recovered 15 inches of the stretch, while under a load of 3,000 pounds it stretched 3 feet 8 inches, or 8 inches more than under the 2,000-pound load. The belt was then run under the 3,000-pound load for thirty minutes without changing its length appreciably.

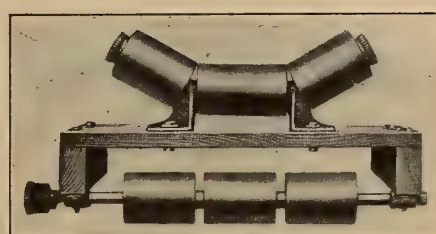
The belt strain caused by the application of the last weight being 1,500, is equivalent to a strees of 31.25 pounds per inch per ply. The belt being 12 inches wide and four ply, this is not far short of the manufacturer's guarantee of 40 pounds per inch per ply as the ultimate working strength of rubber-covered cotton duck belting.

The best method of joining conveyor belts is by butt joint, held together by clamps, similar to ordinary belt fasteners.

TROUGHING OF THE BELT.

Very few belt conveyors are used at the present time with flat belts on account of the larger capacity of troughed conveyors. The ordinary conveyor belt, with uniform plies of duck across the whole surface, is naturally stiff, and, if forced to assume the shape of a deep trough, is bound to suffer, as the adherences between the plies of duck and the rubber coating are strained and distorted by the ever-repeated process of bending. This type of belt, if otherwise suitable for the material to be conveyed, should never be bent more than into a shallow trough.

For deep troughing the type belt advocated by Robins is advantageous, as only a belt of this type can stand the strain of being shaped into



ROBINS' THREE-PULLEY IDLER FOR TROUGHING BELT

a deep, continuous trough; this kind of belt having a natural tendency to trough, as the sides are stiffer than the middle.

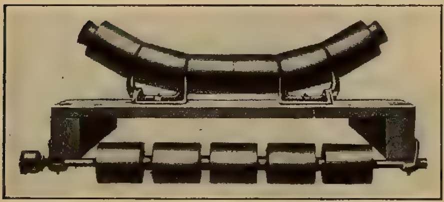
SUPPORTING IDLERS.

As already mentioned, very few belt conveyors are used in which the belt runs on cylindrical idlers only, without troughing, so that all idler rollers of the flat type may almost be looked upon as obsolete. The type most generally in use is that illustrated above, and a modification of the same principle for wider belts, shown on the next page. The former was first introduced by the Robins Conveying Belt Co., about 1885, and is now almost universally used either

as illustrated or with slight variations.

Theoretically, it cannot be considered correct to use idler pulleys of small diameter for narrow belts, and larger ones for wide belts, as is generally the case. The belt-speed should be taken into consideration, and fast-running belts should be fitted with larger, and slow running ones with smaller, diameter rolls. Conveyors for grain and seed, which almost invariably run faster than those for minerals, generally have the smallest diameter idlers, which is obviously wrong, as a glance at the following table illustrates:

With a belt speed of from 200 to 600 feet per minute a 4-inch roller will make from 190 to 570 revolutions per minute.



ROBINS' IDLER FOR WIDE BELTS

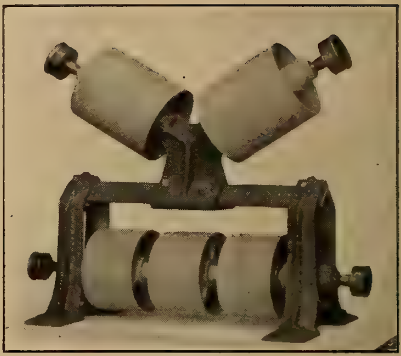
TABLE NO. 2.

A 5-inch roller at the same speed will make 150 to 460 revs.
A 6-inch roller at the same speed will make 125 to 375 revs.
A 7-inch roller at the same speed will make 110 to 330 revs.
A 8-inch roller at the same speed will make 100 to 300 revs.
A 9-inch roller at the same speed will make 85 to 255 revs.
A 10-inch roller at the same speed will make 75 to 225 revs.

From this table it will also be seen that the speed of the idler pulleys, except those of 4 inches and 5 inches, at the high speed, is not too high to ensure satisfactory running, and, if properly lubricated, the weight of the belt alone should be sufficient to turn them easily. Should any of them become stuck it is due to grit or insufficient lubrication.

The greater the number of rollers in each idler frame, and, therefore, the shorter each individual roller, the smaller the chance of damage by attrition to the belt in case of any one roller becoming fast.

The slope of the idler pulleys for troughing, as first introduced, stood

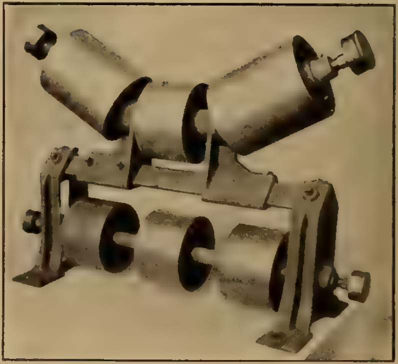


TWO-PULLEY BELT CARRIER. DODGE MFG. CO., MISHAWAKA, IND.

at an angle of 40 degrees to the horizontal, but was subsequently changed to anything between 30 and 25 degrees, so as to avoid too sharp a bend in the belt. Later designs for wide belts use idlers with 5 and 6 rollers, so as to form a trough resembling a section of a circle. This gives sufficient troughing to carry a large capacity, and ensures the centering of the load, thereby increasing the tendency for the belt to run straight.

The illustrations on this and following pages represent idlers made by the Dodge Manufacturing Co. All the bearings are babbitted and fitted with compression grease cups, the spindles being formed of tubing, with suitable lubricating holes in them.

Having dealt with the diameter of the rollers and the general arrange-



THREE-PULLEY BELT CARRIER. DODGE MFG. CO.

ment of the troughing idlers, we will now see how frequent these idlers should be placed under the belt to support it in a satisfactory manner.

This pitch of the supports depends upon the weight of the material to be carried, and also upon the rigidity of the belt, a troughed belt being naturally more rigid than a flat one. The following table gives this information under average conditions and for troughed belts:

TABLE No. 3.

PITCH OF SUPPORTS.

Width of Belt.	Number of Plies in Belt.	Pitch of Idlers. For Minerals.	Pitch of Idlers. For Grain and Seed
Inches.		Ft. In. Ft. In.	Ft. In. Ft. In.
10 to 16	3 to 4	4 6 to 5 0	5 6 to 6 0
18 to 22	4 to 5	4 0 to 4 6	5 0 to 5 6
24 to 30	5 to 6	3 6 to 4 0	4 6 to 5 0
32 to 36	6 to 7	3 0 to 3 6	4 0 to 4 6
38 to 48	7 to 8	2 6 to 3 0	3 6 to 4 0

The idlers supporting the return strand should be about twice as far apart, or, say, from 6 to 12 feet.

The lubrication of the idlers is of great importance. Oil is the best lubricant; but as this is likely o spill on the belt, it is better to use a viscous lubricant, particularly when rubber belts are used, as the oil may injure the rubber. Grease-lubricated conveyors take slightly more power, but grease is a more suitable lubricant, as, when forced into the bearings in the usual way, it forms an effective dust protector for the bearings.

DRIVING TERMINALS.

The driving mechanism of a belt conveyor is the simplest possible. It consists, in its original form, of a terminal or driving drum or pulley, supported by a substantial spindle and pedestals, to which the driving power is applied. The terminal at the other end is similar, but is usually fitted with an adjustment for keeping the belt taut. These terminals are so simple and so well known that there is no call for going into further details, except that the drums should be stronger than ordinary pulleys, with a good rim and sufficient arms, particularly for wide conveyors, and they should be well rounded on the face. It is also advisable to secure the driving drum with two keys at right angles to the spindle.

The following table gives the diameters and widths of terminal drums and guide and idler rollers, which are recommended for ordinary conditions:

If the pulley or drum is less in diameter than the dimensions given in the table, the belt may not be sufficiently pliable to adhere closely to the pulley, and it is, therefore, questionable whether the full benefit of the pressure will be obtained.

TABLE No. 4.

DIMENSIONS OF TERMINALS, GUIDE PULLEYS AND SUPPORTING ROLLERS.

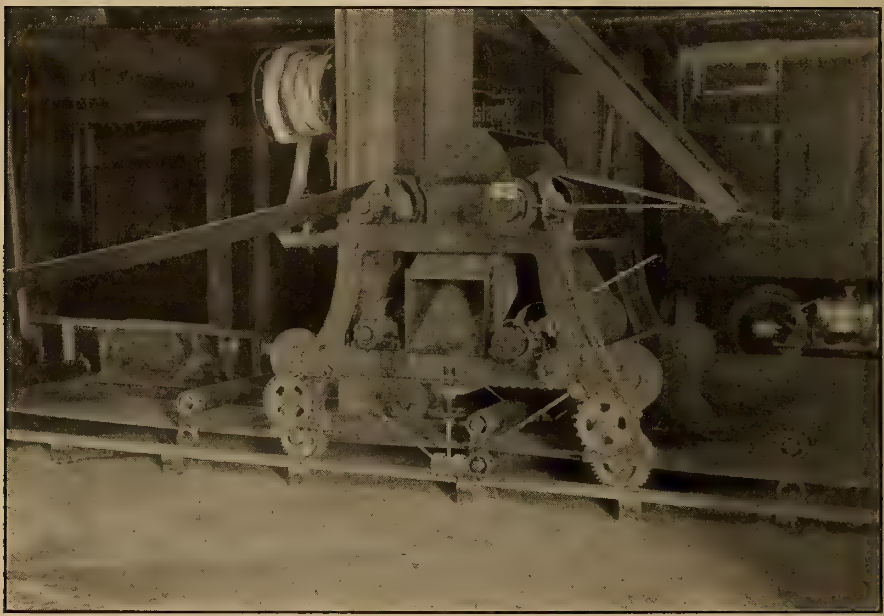
Width of Belt. Inches.	Number of Plies in Belt.	Width of Pulleys and Rollers. Inches.	Diameter of Driving Terminal Pulleys. Inches.	Diameter of End Terminal Pulleys. Inches.	Diameter of Tightening and Throw-off Pulleys. Inches.	Diameter of Supporting Rollers. Inches.
10	3	12	15 to 18	12 to 15	12	4*
12	3	14	15 to 18	12 to 15	12	4*
14	3	16	15 to 18	12 to 15	12	5*
16	4	18	21 to 24	15 to 18	15	5*
18	4	20	21 to 24	15 to 18	15	6
20	4	22	21 to 24	15 to 18	15	6
22	5	24	24 to 30	18 to 22	18	6
24	5	26	24 to 30	18 to 22	18	8
26	5	28	24 to 30	21 to 24	18	8
28	5	30	24 to 30	21 to 24	18	8
30	6	33	30 to 36	24 to 30	21	8
32	6	35	30 to 36	24 to 30	21	8
34	6	37	30 to 36	24 to 30	21	8
36	6	39	30 to 36	24 to 30	21	8
38	7	41	36 to 42	30 to 36	24	10
40	7	43	36 to 42	30 to 36	24	10
42	7	45	36 to 42	30 to 36	24	10
44	8	47	42 to 48	36 to 42	27	10
46	8	49	42 to 48	36 to 42	27	10
48	8	51	42 to 48	36 to 42	27	10

* Fast-running conveyors, at, say, a belt speed exceeding 500 feet per minute, should have 6-inch diameter rollers.

POSITION OF DRIVE.

At first it was generally accepted

that the tight side of the belt should, by preference, be used for conveying, as this is in a flatter condition than the other, this being particularly so in cases of installations with flat belts. This practically meant that band conveyors should always be driven only at the end at which they discharge their load, but it has been fully demonstrated within the last few years that conveyors work equally well on either the tight or slack side of the belt. This has increased the utility of the band conveyor considerably, as under these conditions it is quite immaterial from which terminal the conveyor is driven. Indeed, it might be driven at any point of its length between the terminals by employing multiple pulley drives to get sufficient contact between the driving drums and the belt. For this purpose, the belt passes over two or even more pulleys, which may be geared together, so as to revolve at the same periphery speed. Similar multiple pulleys have also been used for terminal drives in cases of extra long conveyors, and particularly in cases where the conveyor works in dusty places, or where in the cold season there is the possibility of belt and pulleys becoming slippery through dust or ice. To some extent the slip may be prevented by lagging the driving drum with india-rubber, and, according to Mr. Haddock, an advantage of 7 per cent. is obtained in tractive power, so that a drum with rubber lagging will be useful not only for larger conveyors,



GENERAL VIEW OF TRIPPER FOR DELIVERING GRAIN FROM BELT CONVEYOR. DODGE MFG. CO., MISHAWAKA

but also in cases where a slipping may be feared.

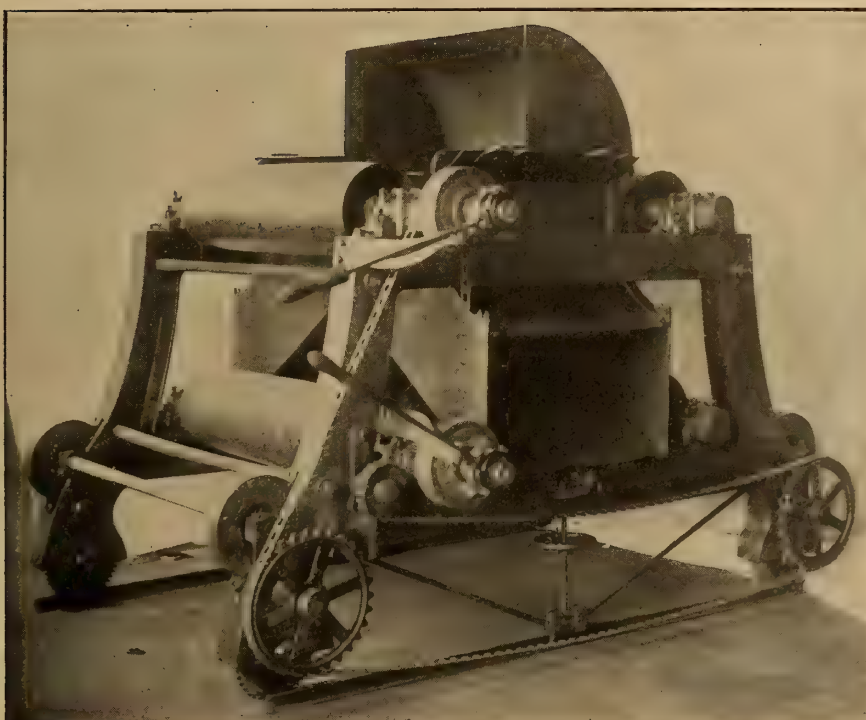
With the single-pulley drive at either of the terminals, the belt must always be kept taut by some tightening device, as the grip of the driving drum on the belt depends upon this, whilst, with a multiple pulley drive, the grip of this group of pulleys on the belt is so great that sufficient tractive force can be exercised without relying on the tension of the belt.

It has been urged that the belt will not stand being bent over pulleys in both directions when in tension,

which is necessary with multiple drives, but with a first-class belt and drums of sufficient diameter no separation of the plies has so far been experienced. It will, however, be well to wait, before giving a final decision on this subject, until installation with multiple pulley drives have been in use for a sufficient number of years, to see whether the life of a belt under these conditions is as long as with the ordinary terminal drive. At any rate, the ability to drive the conveyor from either terminal is of the greatest advantage. Frequently, two conveyors working in the same direction, one from the other, or, from the same point in opposite directions, have been driven by one motor by the latter being situated at the junction of the two conveyors.

DRIVING POWER.

The power required for driving belt conveyors is comparatively small; in fact, there is probably no conveyor system which is so economical on this point. The calculation is influenced by a great number of considerations, of which the number of plies and, consequently, the stiffness of the belt, the distance apart at which the supports are placed, and the nature of the driving arrangement form the principal items, in addition to the load, length, and speed of the conveyor. The method of lubrication and the state of the atmosphere also influence the power consumed, and, as this latter as well as other conditions cannot be considered as permanent, it appears of little use to give formulas for elaborate calculations, as these would

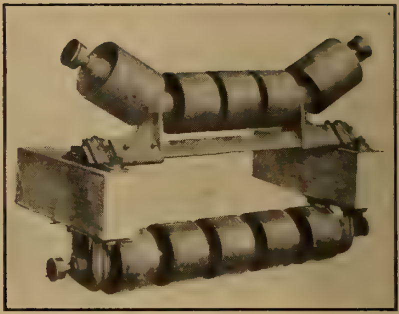


DODGE BELT-CONVEYOR TRIPPER FOR GRAIN. GRAIN MAY BE DELIVERED ON EITHER SIDE; TOP HOOD IS REVERSED BY REVERSAL OF BELT. CONVEYOR SELF-PROPELLED ON TRACK

DODGE IDLER FOR WIDE BELT CONVEYOR

be conveyed at the highest speed, as such materials will not be damaged by being delivered at a great velocity. The limit of speed is, therefore, only set by the resistance of the air to the passage of the material. If the grain or seeds are heavy, a speed of 500 to 700 feet per minute is admissible whilst if it contains much dust or chaff or if the grain itself

only be right for certain specific conditions. Opinions of experts also differ so much on this subject, which has been shown during the discussion on the interesting papers of Messrs. Titcomb, Baldwin, and Peck, read before the American Society of Mechanical Engineers, that it will probably be better, more to the point, and more useful to the user, to give a table of horse-powers calculated to give a sufficient margin of power for small contingencies. This table is for horizontal conveyors:



DODGE IDLER FRAME, SHOWING COMPRESSION GREASE CUPS

TABLE No. 5.

Horse-power Required for Belt Conveyors 100 Feet Long Running at a Speed of 100 Feet per Minute and with a Normal Load of the Different Materials.

	For Handling Heavy Ore.		For Handling Coal.		For Handling Grain.	
Width of Belt in Inches.	Horse-power Consumed by Conveyor.	Additional Horse-power Consumed by Each Throw-off or Tripper.	Horse-power Consumed by Conveyor.	Additional Horse-power Consumed by Each Throw-off or Tripper.	Horse-power Consumed by Conveyor.	Additional Horse-power Consumed by Each Throw-off or Tripper.
10	.775	.25	.540	.25	.486	.25
12	.961	.50	.675	.50	.594	.25
14	1.147	.50	.840	.50	.702	.25
16	1.550	.50	1.080	.50	.810	.50
18	2.013	.75	1.316	.50	.952	.50
20	2.343	.75	1.512	.75	1.092	.75
22	2.838	1.00	1.792	.75	1.358	.75
24	3.636	1.25	2.250	.75	1.740	.75
26	4.320	1.50	2.670	1.00	1.925	.75
28	5.040	1.75	3.090	1.00	2.118	.75
30	5.760	2.00	3.540	1.25	2.310	1.00
32	6.747	2.25	4.096	1.50	2.707	1.00
34	7.254	2.50	4.416	1.75	2.950	1.00
36	8.151	3.00	4.768	1.75	3.200	1.25
38	9.348	3.25	5.635	2.00	3.815	1.50
40	10.168	3.50	6.355	2.00	4.130	1.75
42	10.906	3.75	6.405	2.25	4.725	1.75
44	11.644	4.00	7.790	2.50	5.320	2.00
46	12.505	4.25	7.175	2.75	5.915	2.25
48	13.366	4.50	7.560	3.00	6.895	2.50

It is a surprising fact that the power consumed by a band conveyor running light may be as much as from 35 to 75 per cent of that consumed by the loaded conveyor, the percentage depending principally upon the load, length and speed of the conveyor. It is obvious that the power consumed by the terminals does not increase pro rata with the length of the conveyor and, therefore, the power thus consumed by the terminals of short conveyors may be the principal factor, but it becomes more and more insignificant as the conveyor is lengthened, whilst the power consumed in turning the idlers increases in direct proportion to the length and load of the conveyor, so that with short conveyors when running idle the percentage of power consumed is smaller than with long conveyors.

SPEED AND CAPACITY.

The speed and capacity of belt conveyors depend entirely on the nature of the material to be handled and the width and shape of the belt. Materials like grain and seeds can is light, like oats, the speed should not exceed 400 to 600 feet per minute.

The speed of belts for coal and minerals is altogether different. Here the speed is, in many cases, limited

BELT CONVEYOR IN OPERATION HANDLING MILL TAILINGS IN A LARGE CYANIDE PLANT. JEFFREY MFG. CO.

by the friability of the material and the consequent dust creation and deterioration of some materials through the impact at the delivery point. This refers particularly to coal and coke. There is an exception to this in cases in which the material does not deteriorate by breakage at the impact, but where the band has to run slower on account of fine material being mixed with the coarse, so that the same consideration comes into force as in the case of grain conveyors.

The shape of the belt has also a great influence on the capacity, and flat or very shallow belts cannot carry as much as deeper troughed belts. The following table gives the safe load for a belt, in cubic feet per minute, by multiplying the area of an uniform load with the speed in feet at which the belt travels:

TABLE No. 6.

SHOWING SECTION OF LOAD IN SQUARE FEET WHICH CAN BE CARRIED WITH SAFETY, IF THE MATERIAL IS SMALL AND UNIFORM, IN A CONSTANT STREAM ON BELT CONVEYORS.

Width of Belt in Inches.	Area or Cross Section of Load in Square Feet. For Flat Belts.	For Troughed Belts.
10	0.015	0.05
12	0.026	0.06
14	0.042	0.08
16	0.055	0.11
18	0.07	0.15
20	0.085	0.18
22	0.114	0.23
24	0.139	0.28
26	0.164	0.33
28	0.19	0.40
30	0.203	0.47
32	0.253	0.53
34	0.29	0.60
36	0.33	0.66
38	0.367	0.75
40	0.41	0.83
42	0.455	0.91
44	0.506	1.00
46	0.557	1.08
48	0.608	1.12

TABLE No. 7.

Capacity of Belt Conveyors for Grain and Seeds.

Width of Belt in Inches.	Capacity in Tons per Hour at a Belt Speed of 400 Feet per Minute. Heavy Grain.	400 Feet per Minute. Light Grain.	500 Feet per Minute. Heavy Grain.	500 Feet per Minute. Light Grain.	600 Feet per Minute. Heavy Grain.	600 Feet per Minute. Light Grain.	700 Feet per Minute. Heavy Grain.	700 Feet per Minute. Light Grain.
10	8	6	10	8	12	10	14	11
12	15	10	18	12	22	14	26	17
14	22	14	27	18	33	22	38	25
16	30	19	37	24	44	29	51	34
18	37	26	46	32	55	38	65	45
20	47	32	58	40	70	48	82	56
22	60	40	75	50	90	60	105	70
24	73	48	92	60	110	72	128	84
26	87	58	108	72	130	86	152	101
28	100	67	125	84	150	101	175	118
30	116	78	145	98	174	118	203	137
32	133	90	167	112	200	134	233	157
34	153	102	192	128	230	154	268	179
36	173	116	217	145	260	176	303	203
38	193	130	242	162	290	194	338	227
40	217	144	271	180	325	216	379	252
42	240	160	300	200	360	240	420	280
44	266	176	333	220	400	264	466	308
46	293	192	367	240	440	288	513	336
48	320	212	400	265	480	318	560	371

TABLE No. 8.

Capacity of Belt Conveyors with Troughing Rollers for Minerals.

Width of Belt in Inches.	Capacity in Cubic Feet per Hour at a Belt Speed of 100 Feet per Minute.	Maximum Advisable Speed in Feet per Minute.	Capacity in Cubic Feet per Hour at the Maximum Advisable Speed.	Largest Piece of Mineral to Exceed in Inches.	Speed of Belt in Feet per Minute for Conveying Coal Containing Pieces of the Size Given in the Previous Column.	Capacity per Hour of Coal as per Previous Column. Cubic Feet.	Capacity per Hour of Coal as per Previous Column. Tons.
10	....	...	......	..	...	.....	...
12	400	300	1,200	2	300	1,200	24
14	500	300	1,500	2	300	1,500	30
16	700	300	2,100	3	300	2,100	40
18	900	350	3,150	4	275	2,475	50
20	1,100	350	3,850	5	275	3,025	60
22	1,400	400	5,600	6	250	3,500	70
24	1,700	400	6,800	8	250	4,250	85
26	2,000	450	9,000	9	225	4,500	90
28	2,400	450	10,800	12	225	5,400	108
30	2,800	450	12,600	14	200	5,600	112
32	3,200	500	16,000	15	200	6,400	128
34	3,600	500	18,000	16	200	7,200	144
36	4,000	500	20,000	18	180	7,200	144
38	4,500	500	22,500	19	170	7,650	153
40	5,000	550	27,500	20	160	8,000	160
42	5,500	550	30,250	21	150	8,350	165
44	6,000	600	36,000	22	140	8,400	168
46	6,500	600	39,000	23	130	8,450	169
48	7,000	600	42,000	24	125	8,750	175

The approximate capacities of conveyors for grain and seeds will be found from Table No. 7, whilst Table No. 8 gives the capacity of belt conveyors for minerals and coal:

As with other conveyors, the same maxim holds good for the widths of belt conveyors, *i. e.*, if the capacity is great, the width of the belt is determined by the load, but where the quantity is small and contains large pieces, the size of the largest piece determines the width of the belt. In both cases the speed of the belt should not be faster than is necessary to carry the load, and it is often better to carry a bigger feed on a slower belt than a thinner feed on a faster belt. As a general rule it may be taken that belt conveyors for:

	The Speed of the Belt may be from
Minerals....................	400 to 700 feet per minute.
Heavy grain and seeds.......	500 to 700 feet per minute.
Light grain..................	400 to 600 feet per minute.
Coal and coke...............	300 to 500 feet per minute.
Sacks and other big loads....	150 to 300 feet per minute.
Passengers..................	100 to 150 feet per minute.
Sorting and picking..........	20 to 60 feet per minute.

The belts of conveyors generally keep clean from adherence of the

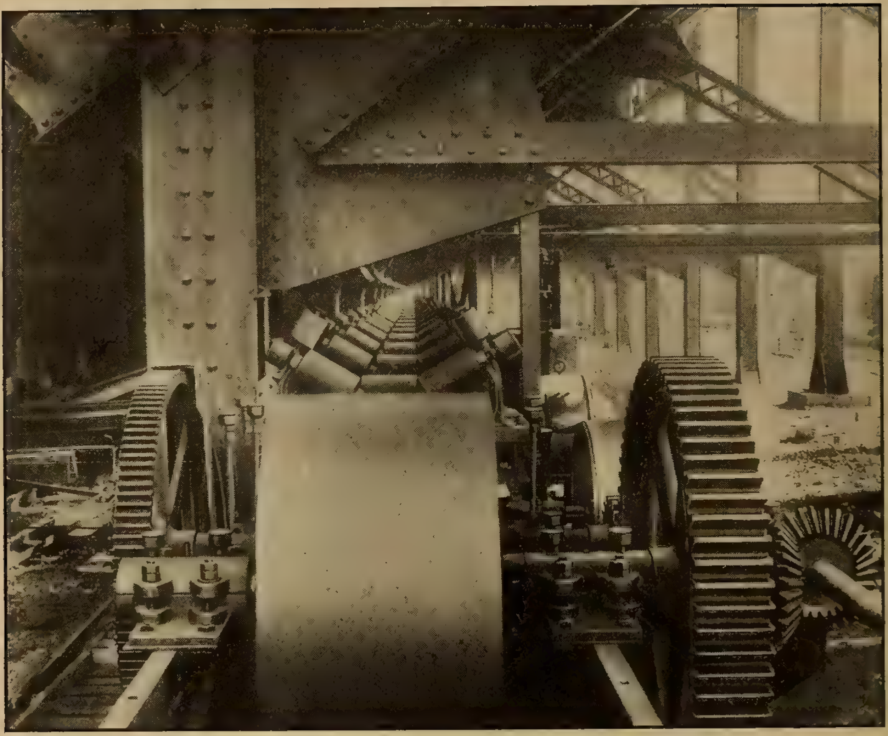
materials they carry, but with some materials, such as clay, sugar, salt and other sticky substances, there is a tendency for the belt to convey small particles past the delivery point, where it may become a nuisance. In such cases rotary brushes (manipulated from the belt) have been used successfully. Where materials containing acids or other corrosive fluids are conveyed by belt conveyors, the whole of the metal portion of the machinery part, including the finished surfaces, should be painted with graphite or white lead paint.

INCLINED BELT CONVEYORS.

Belt conveyors can be used not only in a horizontal position, but also with a slight upward or downward gradient. They can also be designed so as to embody all these three attributes in one and the same conveyor, provided the change from one to the other is accomplished by a gentle curve.

Materials like loose gravels, pebbles, or clinkers from revolving kilns,

BELT CONVEYOR ARRANGED AS A PICKING TABLE IN A SOUTH AFRICAN GOLD MINE. JEFFREY MFG. CO.



DRIVING MACHINERY AND IDLERS FOR BELT CONVEYOR 1,082 FEET LONG, SHOWN UNDER CONSTRUCTION. THIS INSTALLATION IS FOR HANDLING COKE AT THE PLANT OF THE TENNESSEE COAL, IRON & RAILWAY CO. THE JEFFREY MFG. CO., BUILDERS

or all-round materials, which have a tendency to run backward, must not be conveyed on an upward gradient of more than 10 to 15 degrees.

Conveyors for all other materials containing large pieces may have an upward gradient of 15 to 20 degrees, if desirable, whilst material of a uniform and fine nature, such as sand, small coal and minerals, will negotiate an incline up to a maximum of 23 degrees.

ANALYSIS OF POWER DISTRIBUTION IN A COTTON-SPINNING FRAME

By Albert Walton

CERTAIN general facts have been known for many years concerning the power in the spinning room of a cotton mill and its laws of variation throughout a normal day's run. It has been possible to take more or less accurate measurements at the engine cylinder by indicator cards and, at the expense of much toil and pains, to ascertain that the power is very noticeably higher during the first fifteen minutes of the morning and that after abruptly falling from this starting peak there is a more gradual diminution throughout the remainder of the first hour and a steady but very slight decrease during the entire forenoon. The cards sometimes showed a lesser peak after the noon hour and a very gradual decline throughout the second half of the day, the day's minimum occurring at its end. This, it should be noted, is a day's power history for a unit consisting of a great number of spinning frames, each in turn being an aggregation of many spindles. In fact, to secure reliable data by this method it is imperative that the unit be very large, so that other variables, such as belts, journals and shafts, may not, by undue percentages, mar the accuracy of the results. Not uncommonly these readings and computations were made in connection with spinning departments of fifty thousand spindles, or over two hundred distinct machines. Obviously the figures obtained will be broad averages, and will give no information whatever of the power changes of a single frame. In fact, little is generally known among mill men even to-day in regard to the momentary changes that occur during the repeated cycles of the process of filling a set of bobbins with spun yarn. It is, of course, out of the question to secure any data of this nature in a mill driven as a unit from a large engine, inasmuch as a single frame would not show on the indicator cards, even assuming they could be taken for each stroke of the engine, and it is impossible to cause the cycles of a large group of frames to so synchronize as to raise these fluctuations to a point where they will be measureable on the engine.

The utilization of the large electric motor to drive groups of these frames, though it much simplified the securing of the average values and permitted greater accuracy and refinement, did not in any way contribute to the knowledge of what was occurring in the individual frame. It remained for the simultaneous development of two factors and their combination during the past two years to reveal this very interesting information. Not only was it necessary to wait for the adoption of the individual motor to each frame, but also for the production of an adequate recording meter which would give a continuous chart displaying every fluctuation in power taken by such a motor. Both of these features are now commercial realities, and it has been the writer's good fortune to secure by this method some very interesting data. This meter is shown in the accompanying photograph mounted upon a semi-portable truck, together with other meters and transformers. (Fig. 1.) By con-

necting this testing set in the motor circuit and properly adjusting the component parts most instructive and reliable data can be secured. We have copied here one of the charts obtained and propose to discuss it in detail.

For the benefit of the "lay reader" who may not be fully conversant with the details of a cotton-spinning frame a few words of explanation may not be amiss to put him in touch with the essentials.

Figure 2 is a photograph of the driving end of a motor-driven ring spinning frame. A rigid tin cylinder "A" runs the entire length of the frame, which is about thirty feet long. It is about seven inches in diameter and is centrally located between the two rows of spindles, "B," on each side of the frame. The purpose of the cylinder is to drive the spinning spindles. This it accomplishes by means of small cords or "bands," "C," which serve as driving belts. Each band passes from the cylinder to the grooved, or "whorl," "D," on the spindle, which is usually less than an inch in diameter. For every revolution of the cylinder, therefore, the spindle makes seven or eight complete turns. The usual practice is to arrange for from one hundred to one hundred and fifty spindles on each side of the frame. Figure 3 is a diagrammatic sketch showing the arrangement of cylinder, bands and spindles, while Figures 10 and 11 show a general view of the spinning frames as installed in modern mill practice. The spinning process is briefly as follows: Two strands of coarse, partially twisted yarn, called "roving," are led from bobbins ("E" Figs. 2 and 3), on which they have previously been wound down between two pairs

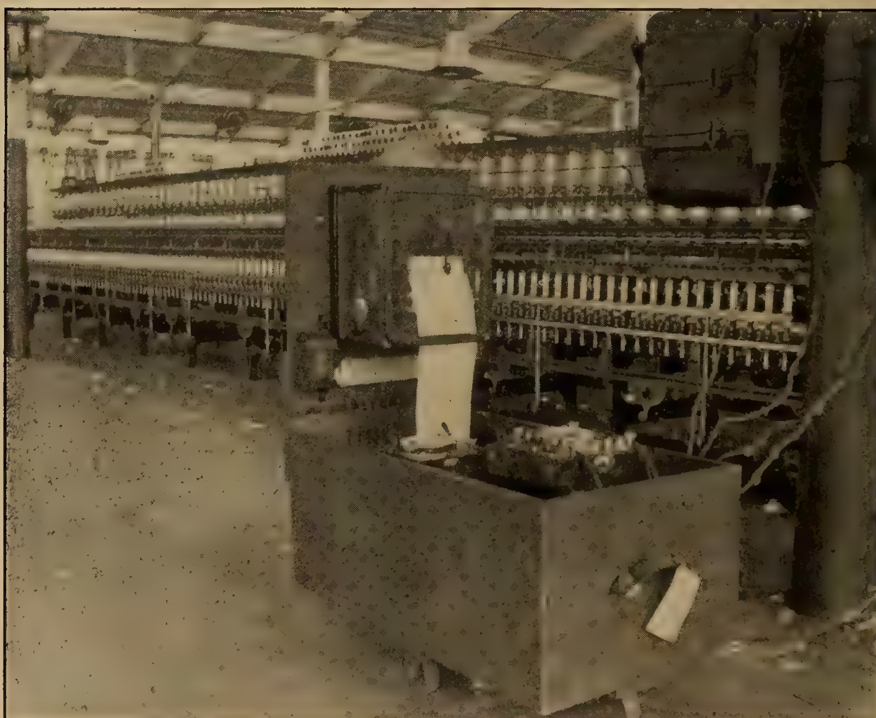


FIG. 1.—TESTING SET IN OPERATION, SHOWING WESTINGHOUSE GRAPHIC RECORDING WATTMETER

of slowly revolving rollers which hold the strands firmly between them while passing them forward to a third pair ("F"), which are similar but revolve seven or eight times as fast. There is thus an attenuation of the strands by drawing the fibres one upon the other. No stretching of the cotton takes place, merely a rearrangement or sliding upon themselves of the fine fibres, so that there are fewer of them side by side. Thus as they emerge from the third rollers they are in the form of a fine, practically untwisted and, therefore, very weak thread. To make them serviceable they must be twisted and neatly wound on a bobbin, and this is done in the following manner: The spindle (Fig. 4) is centrally situated in a ring (Fig. 5) mounted upon a rail ("G," Figs. 2 and 3), which moves up and down the length of the bobbin. Upon this ring is a small "C"-shaped spring-steel "traveler," which, though it is sprung over the side of the ring, as shown in Fig. 6, is yet free to revolve around the ring, the latter being highly polished, to minimize the friction of the traveler. The yarn leaving the rolls, passes down to a guide-eye ("H," Figs. 2 and 3) located exactly over the center of the spindle. From there it is led through the "C"-shaped traveler on the ring to the bobbin. When the frame starts, the rolls feed out the untwisted yarn. The bobbins on the spindle revolving at a high rate of speed, attempt to wind up the yarn. If the traveler were fixed in one position on the ring the yarn would be wound on at a rate tremendously in excess of the rate of feed at the rolls and would be instantly broken. Being free on the ring, however, the traveler is carried around the ring at a speed practically equal to that of the spindle. Were it to travel at exactly the same speed in revolutions per minute the yarn would not be wound on the bobbin at all. Its

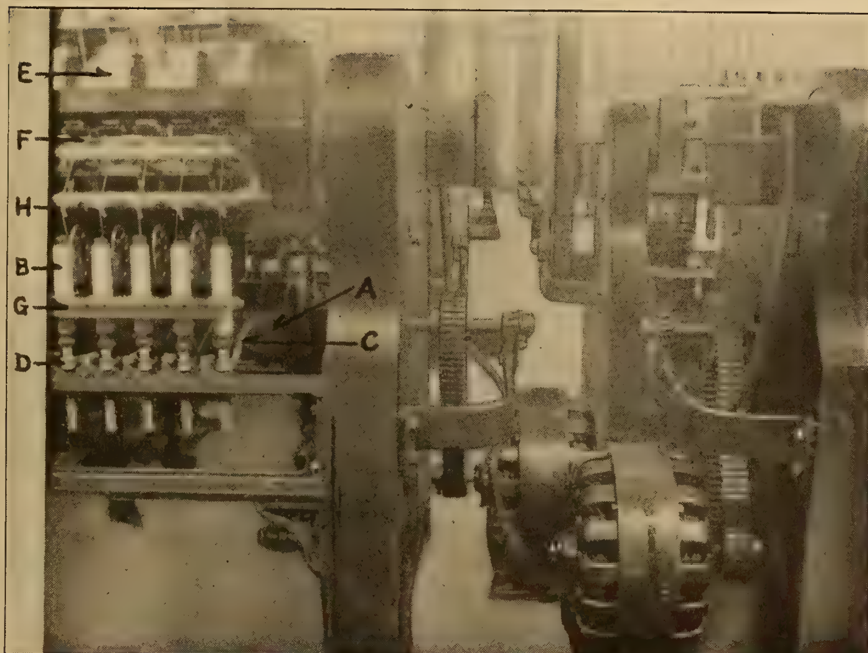


FIG. 2.—MOTOR-DRIVEN RING SPINNING FRAME

A, cylinder; B, spindles; C, bands; D, whorl; E, roving bobbins; F, drawing rolls; G, ring rail; H, guide-eye

friction and the air friction of the yarn passing through it cause it to lag behind the speed of the bobbin by enough to wind upon the bobbin the yarn being fed to it by the rolls. For example, if one wrap around the bobbin be three inches and the rolls are feeding one hundred and fifty inches of yarn per minute the traveler would lag behind enough to wind on this one hundred and fifty inches, or fifty revolutions each minute. The spindle meanwhile is revolving at a speed of from five thousand to twelve thousand revolutions per minute, thus twisting the yarn as it descends through guide-eye and traveler to the bobbin. The function of the revolving spindle and bobbin then is to twist the fine filaments into a thread, while that of the traveler is to provide a drag sufficient to wind the yarn on the rapidly revolving bobbin. In order to neatly wind a bobbin in even layers a device automatically raises and lowers the "ring-rail" ("G," Figs. 2 and 3) at a rate that will equal the thickness of the yarn for each wrap that the traveler causes to be wound on the bobbin.

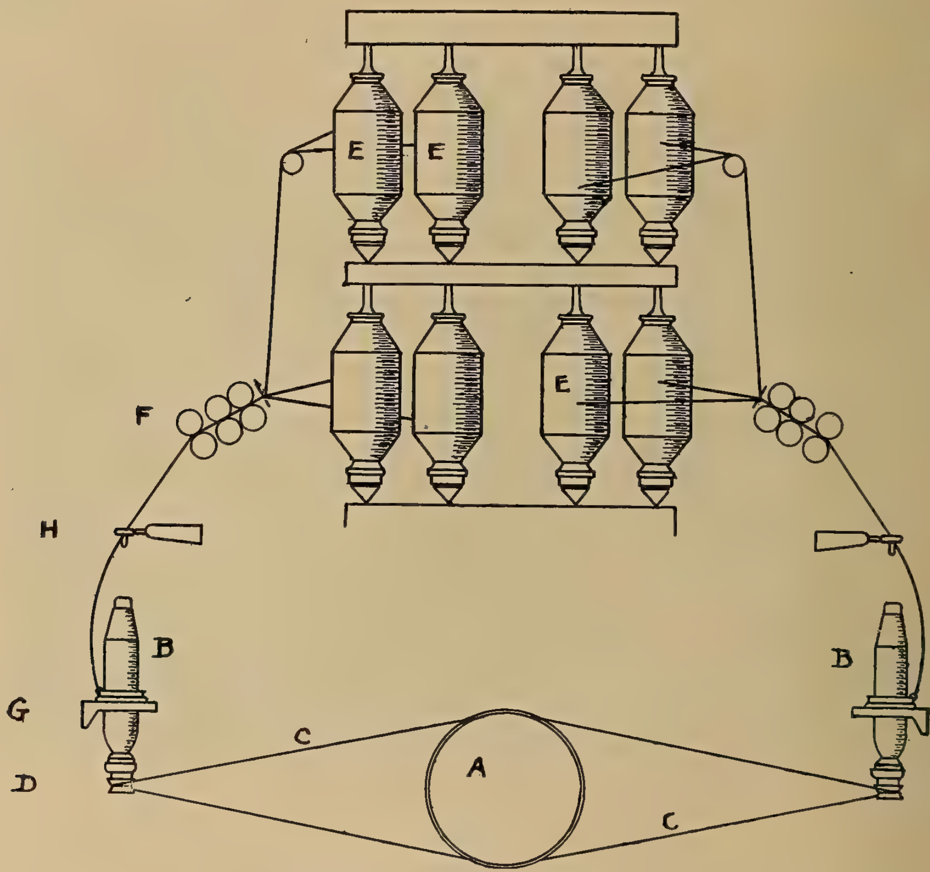


FIG. 3.—COMPONENT PARTS OF A RING SPINNING FRAME

A, cylinder; B, spindle with bobbin; C, band; D, whorl; E, roving bobbins; F, drawing rolls; G, ring rail; H, guide-eye

This, then, is the cotton-spinning process that is carried on simultaneously on each of the two hundred and fifty spindles of each frame, and it is because of the fact

that in a room with a great number of frames in operation no two would have their ring-rails "in step," rising and falling together, and because the bobbins are in various stages from the empty wood to the fully wound bobbin ready for removal, that it is impossible to obtain any detailed information in regard to the power fluctuations for a single frame with anything but an individual motor and a curve-drawing meter.

FIG. 4.—SPINNING SPINDLE

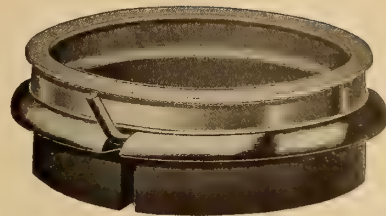


FIG. 5.—DOUBLE RING IN CAST-IRON HOLDER, WITH WIRE TRAVELER CLEARER

The curve shown in Fig. 7 is a reproduction of one drawn by the Westinghouse Graphic Recording Wattmeter shown in the illustration (Fig. 1) mounted on the portable testing truck, and is a true history of the power fluctuations for an entire day for the motor-driven frame, the driving end of which is shown in Fig. 2. To read this chart intelligently it is only necessary to know that the paper is fed out lengthwise under a pen that moves crosswise a distance proportional to the amount of power being measured. Thus, when no power was being used, the pen traced a line which coincides with the bottom or zero line of the paper. Each heavy vertical or cross line on the paper represents the beginning of an hour as marked at the bottom of the chart and each intermediate fine line the intervening half-hour points, while for every 0.2 kilowatts (or 0.268 horse-power) being consumed the pen moves one fine division, the total distance across the sheet denoting six kilowatts (8.05

FIG. 6.—ENLARGED SECTION OF DOUBLE RING, SHOWING TRAVELER IN POSITION

horse-power). Both of these scales are marked on the chart for convenience.

These curves show, in addition to the specific details which we will consider later, the general and well recognized characteristics of a spinning frame load. It is plainly visible that the frame took more power immediately after starting up than for any subsequent period. The customary rapid falling away in the first half hour is portrayed and the similar peak just following the noon hour. The very steady average value is also noticeable. There are no violent fluctuations or sudden peaks. In addition to these well known facts are the more striking characteristics of the individual frame, and these will bear minute analysis and explanation.

The curve consists of three main parts, which have the following meaning: The frame was started at 5:55 A.M. with the bobbins three-quarters filled. At 8:07 the bobbins were filled and the frame shut down to permit the removal of these and their replacement by empty bobbins on the spindles, which was accomplished by 8:10. It took until 1:38 P. M. to fill these bobbins, the frame having stood idle during the nooning of about forty minutes. At 1:45 P.M. the frame was ready for a new start with a new set of empty bobbins, which it just completely filled by the end of the day's work, the complete cycle taking about four hours and thirty-five minutes. This process of removing the filled bobbins when replacing them with a new set of empty ones is called "doffing."

Three salient features of the curve challenge immediate attention and require explanation:

(1.) The power is greater by about twenty per cent. when the bobbins are full than when empty.

(2.) The curve is a regular recurrence of small waves or peaks.

(3.) The form of these waves changes as the bobbin fills.

There are one or two items of

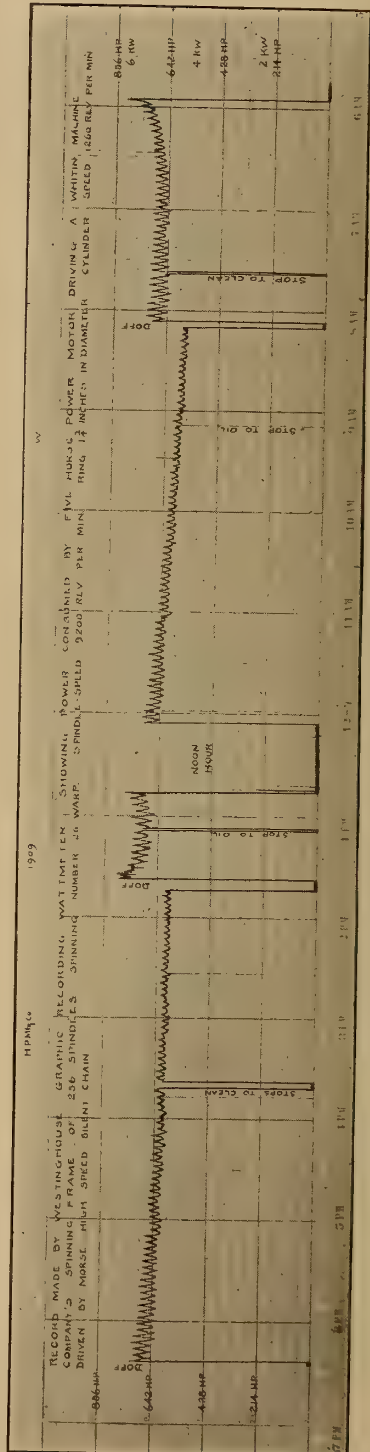


FIG. 7.—REPRODUCTION OF CHART, TAKEN BY WESTINGHOUSE GRAPHIC RECORDING WATTMETER

minor importance, also, which we will mention later. Our principal interest here, however, lies in the discussion of these three statements.

Why should the power be greater with the full bobbin than with the empty? The writer has put this question to many practical mill men, and with perfect unanimity they have all replied that it is due to increased weight on the spindles. Our experience leads us to believe this has little or nothing to do with it. In order to check our theory out we disconnected all the moving parts of a motor-driven spinning frame except the cylinder, bands and spindles and connected a meter into the motor circuit to register the exact power consumed. The bobbins were full, but there was no spinning in progress since the rolls had been disconnected. There was, therefore, no traveler drag and no roll nor creel power to consider. The power was noted and found to be 4.9 H.P. The full bobbins were then removed and the bare spindles continued in motion. The power then read 3.92 H.P., or a loss of 0.98 H.P., by removal of the full bobbins, each of which weighs approximately three ounces, only about one half of which is cotton, the remainder being wood. If, now, the weight on the spindle is the factor to be considered the power will increase by one half of what it fell off if we put the empty bobbins back on the bare spindles in place of the full ones. When this was done, however, the rise was not appreciable, indicating that weight on the spindle is not the factor causing the rise in power with the filling of the bobbin, and we must look elsewhere for our explanation. It is the writer's opinion that this increase is almost wholly a fanning action at the surface of the bobbin, and, as will be seen later, the alteration of the form of the peaks tends rather to bear this out. Neither the bare spindle nor the polished wood bobbin causes any appreciable disturbance of the air in its immediate vicinity. The surfaces are too smooth to have any fanning effect worth considering. As soon as this smooth surface is covered with a few layers of cotton yarn, however, the immense numbers of minute fibres projecting into the air from the surface of the cop have great faculty for stirring up the air. Simultaneously with this change of surface the peripheral velocities are augmented with increasing diameters, and this change in itself makes for marked difference, since the power

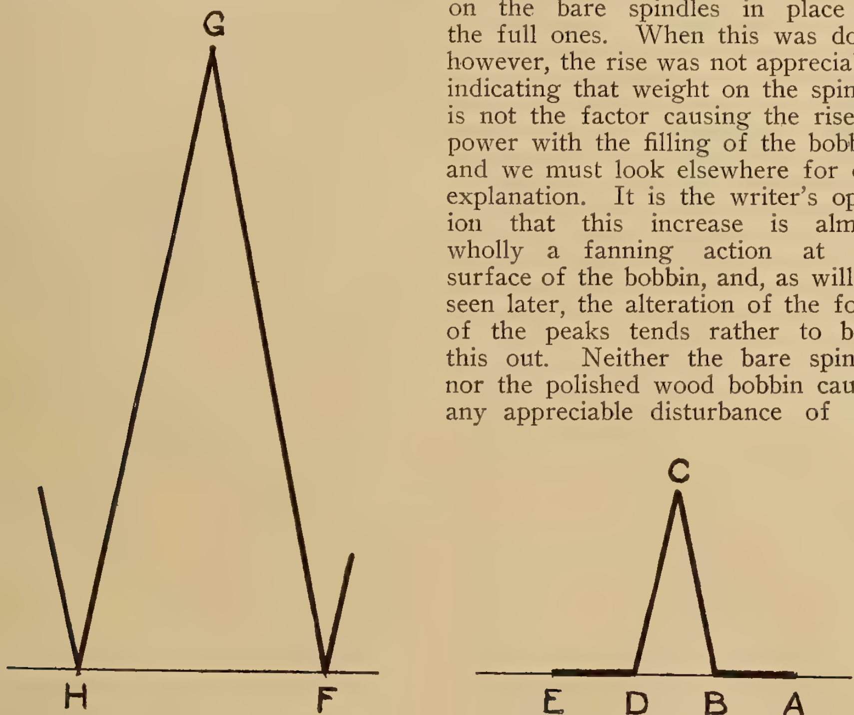


FIG. 8.—FORM OF CURVE FOR FULL BOBBIN, AND FORM OF CURVE FOR EMPTY BOBBIN

required to move air varies with the cube of the speed. If we add these two effects together we can readily understand that the power may well be influenced to a much greater extent from this cause than by mere increase of weight due to a small addition in the shape of yarn wound on the bobbin. This is farther borne out by the crude method of feeling the effect upon the bare hand or face or by holding a fine strand of yarn near the spindles. When empty almost no air motion is perceptible, while when full a strong, vigorous circulation is set up, the air being violently agitated for the entire length of the frame. A piece of fly or dust in the air will frequently be seen to be driven for many feet by these currents before settling to the floor. This, then, we believe, accounts for the steady rise in power from empty to full bobbins. It is seen to be an item of importance, although it is one which, so far as we know, has never been given any prominence whatever. We have examined many treatises and text books without finding the matter mentioned, yet it affects the power of the frame by a full twenty per cent.

The second item of interest shown by the chart, namely, the recurrence of the small peaks, is due to the "traverse" or rise and fall of the ring-rail which guides the yarn onto the bobbin during the winding process. The weight of this rail is counterbalanced by a number of cast-iron weights beneath the frame. At first thought it would appear that these peaks existed because of over-counterweighing, since the power increased as the rail descended and *vice versa*. In fact, this was the explanation given by several mill men to whom the curves have been submitted. But were this the case the peaks would consist of a series of short horizontal lines connected by short vertical lines, since at the top of the traverse there would be an abrupt rise in power, due to lifting the excess weight of the counterweights. This would be constant till the bottom was reached and then would come to an abrupt drop to the low value, which would again be constant throughout the rise. Furthermore, the curves would be decreasing in amplitude as the bobbins were filled, since the leverage on the bobbing-forming device, or "builder," is constantly shortening and therefore making it easier for the cam to operate the rail. But exactly the reverse of this is the case, the amplitude increasing in spite of this feature. We must, therefore, look to some other condition, also changing gradually throughout the filling of the bobbin, and occurring in synchronism with the rise and fall of the ring-rail. Light is thrown on this by the third item we have mentioned.

Third Item. The form of these waves changes as the bobbin fills. We have sketched and enlarged view of these peaks to show their differences. (Fig. 8.)

Owing to the fact that the force necessary to overcome the frictional resistance of the traveler as it is dragged at its high speed around ring must come from the bobbin through the strand of yarn passing from traveler to bobbin (this force remaining constant, since the speed is constant) the total pull on the yarn will vary widely from empty to full bobbin. The component of the yarn pull which drags the traveler around the ring is the component tangential to the ring's circumference. ("A," Fig. 9.) To maintain this component constant the total pull, "b," will be greater when the yarn is pointing nearer the center than when the bobbin is full and the total pull is more nearly tangential. Thus, when the bobbin is empty, this greater tension on the yarn prevents that part of it from guide-eye to traveler from "ballooning," or flying out in a bow driven from the bobbin's axis by its own centrifugal tendencies. The reduced tension at the full bobbin is not sufficient to hold this strand close to the revolving

bobbin, and a pronounced ballooning takes place. Plates have been placed between the spindles to prevent the yarn on adjacent spindles from interfering at this period. The force necessary to propel this strand of yarn through the space about the bobbin is small but appreciable, and when multiplied by two-hundred and fifty, the number of spindles, is an item that must be considered. When no ballooning takes place this section, about eight inches long, lies close to the spindle, and is, therefore, revolving in the air that is propelled by tion to the time ballooning occurred. Referring to the enlarged curves we have at "A" (Fig. 8) a reproduction of the curve with the empty bobbin. With the ring-rail at the top position the power was a minimum ("a"). It remained constant till the rail had passed somewhat beyond the mid-position ("b"), when the stretch of yarn from guide-eye to traveler had sufficient length to start ballooning. Immediately the power rose and continued ascending till the rail turned the lowest position ("c"),

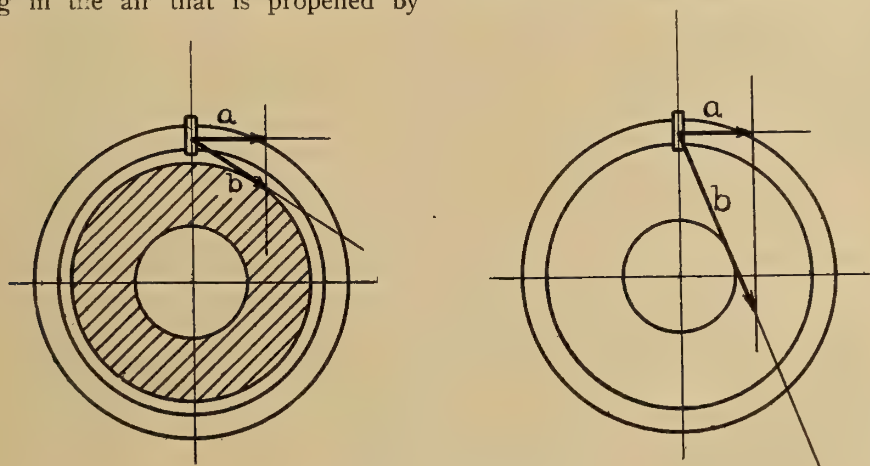


FIG. 9.—FULL BOBBIN AND EMPTY BOBBIN

b, Total pull; a, Tangential component

the spindle itself at the same rate the yarn is traveling. The yarn, therefore, really cuts very little air for this reason. When it flies out as a "balloon," however, it not only passes out of the immediate whirlpool of its own spindle into the dead air outside its influence, but on the sides toward both its neighboring spindles it cuts into the whirlpools set up by these other spindles and by the other revolving sections of yarn similar to itself, and these eddies, being adverse in direction, each segment of yarn is cutting either dead air or air moving rapidly against its direction of rotation.

In confirmation of this theory it was noticeable that the tracing of the power curve bore a direct rela- when the ballooning was at its maximum. As the rail rose, shortening the length of revolving yarn, the balloon was drawn in and the power decreased until the yarn assumed the straight line form, when the power again reached its minimum ("e"), where it remained constant until the rail again reached the top position.

With the full bobbin a curve like that shown at "B" is traced. Ballooning starts immediately when the rail leaves the top position and the power immediately starts to increase and continues to rise as the balloon increases with the descending ring-rail, the condition reversing as the rail again ascends.

This appears to be the only logical

explanation of the difference in power requirements for the beginning and end of the winding process. The total curve, then, is a combination of the two features just described, namely, the fanning of the air, due to increased bobbin diameter, and the air friction, due to ballooning. It is commonly stated by spinners that the "traveler drag" is an important portion of the power required by ring frames, but the fact that this drag is constantly decreasing as the bobbin fills up and yet the power is as constantly increasing would seem to confirm our conclusion that it is rather the air resistance than the traveler drag which is of moment.

Incidentally our chart shows one or two minor items of interest. It will be noticed that just before the doff or removal of the full bobbins at 8:07 A.M. and again at 1:38 P.M. the curve becomes ragged and irregular. This was caused by the fact that the bobbins were allowed to over-fill and rub against the ring and traveler. In the run from 8:07 A.M. to 1:38 P.M. we can count seventy-eight traverses of the ring-rail, while from 1:40 P.M. to the close of the day, when the frame was again ready to doff, but seventy-five traverses occurred and no interference was noted.

FIG. 10.—SPINNING FRAMES AT THE CHICOPEE MFG. CO. MILL, CHICOPEE FALLS, MASS. DRIVEN BY WESTINGHOUSE TEXTILE TYPE MOTORS

Our curve also shows that stops were made at irregular intervals to put on broken bands and to clean the frame at the driving end.

As explained in our opening remarks, it is only within the last few months that instruments for making such records have been available.

FIG. 11.—SPINNING FRAMES MADE BY LOWELL MACHINE SHOPS. DRIVEN BY WESTINGHOUSE MOTORS IN MILL OF WEST BOYLSTON MFG. CO., EASTHAMPTON, MASS. (TAKEN WHILE IN OPERATION, HENCE RING RAIL DOES NOT SHOW)

A minute analysis of the power changes taking place in a frame has been impossible, though it has always presented a field for interesting speculation. This is one of a multitude of cases where the individual motor has enabled the investigator to compel machines to give up their secrets and show forth in black and white all that has for years been taking place unsuspected and concealed from even the most inquiring minds.

Similar power curves have been made on all the other machines in a cotton mill, and these will be discussed in a similar manner in subsequent papers.

A HIGH-SPEED CORLISS ENGINE

By Samuel S. Webber

The accompanying bit of engineering history will be found of much interest in connection with the present transformation which is going on in the design and construction of prime movers. Such chapters in the history of actual engineering experience are too often lost, and we feel gratified at the opportunity of preserving the record of a successful piece of pioneer work.—The Editor.

AMONG recent obituary notices of the late Mr. Edwin Reynolds, of Milwaukee, I have read one which mentions the high-speed 20-inch by 42-inch Corliss engine, designed by Mr. Reynolds for The Trenton Iron Co., and the statement was made that the then leading builder, George H. Corliss, would not consider the order, leaving it to be inferred that the engine was built elsewhere. This is incorrect, as the engine referred to was built at the George H. Corliss Works in Providence, R. I., in the years 1876-1877; and a conversation between Mr. Reynolds and the writer concerning this engine may be of interest at this time.

In preface to this conversation, I may state that the Trenton Iron Co. were in 1876 installing a Belgian 3-high-roll train, for rolling steel rods, and required an engine to drive the train at what was then considered high speed. The train was in two sections: the roughing section had 12-inch rolls, and was to be driven direct from the engine shaft at 160 revolutions per minute; the finishing train had 10-inch rolls, and was to run at 355 revolutions per minute, and be driven from the same engine by belt, the engine having a pulley fly-wheel 10-feet diameter by 30-inch face, belted to a 54-inch by 30-inch pulley, attached to the spindle of the 10-inch roll train.

There was but one maker of engines in the United States who had ever built, or was prepared to build, an engine for this service, namely, Mr. Charles T. Porter, builder of the Porter-Allen engine. It happened, however, that the Corliss Engine Works in Providence were given an opportunity to submit a bid, and, to the surprise of everyone, Mr. Reynolds came to Trenton and said he was prepared to build a Corliss engine for the required service, and solicited the order. A comparison of prices, time of delivery, and guarantee of performance resulted in the order being given to the Geo. H. Corliss Engine Co., of which Mr. Reynolds was then superintendent.

Mr. Corliss at the time was in Europe, and Mr. Reynolds was in full charge of the works during his absence. About two months after the order was taken, Mr. Corliss returned to Providence, and as soon as his attention was called to the order for the engine for Trenton he sent for Mr. Reynolds. I will now quote Mr. Reynolds' own words as related to me, the conversation between Mr. Corliss and himself:

"Mr. Corliss called me to his office, and appeared to be in a high temper. He said: 'What does this mean? How came you to take an order for an engine for such speed and purpose? It's unprecedented, and the most dare-devil piece of engineering I ever heard of. I won't have anything to do with it—you must take all responsibility on your own shoulders.' I told Mr. Corliss that I knew I could build an engine that would successfully meet the condition, and explained the matter to him in detail, showing him how I had designed the engine, and telling him that the work was already in prog-

HIGH-SPEED CORLISS ENGINE AT THE TRENTON IRON COMPANY, 1876—1900

ress, and I felt bound to finish it. Mr. Corliss finally consented to the engine being finished, but refused to take the responsibility for its acceptance, so I said I would be responsible for it, and must take the blame and expense if it did not do the work and receive acceptance from The Trenton Iron Co."

Therefore, the engine was built and set up at Trenton, ran at the speed of 160 revolutions per minute, a piston speed of 1,120 feet per minute, drove the rolling mill, and so continued for over twenty years, running eighteen hours out of the twenty-four a day and night turn of nine hours each, much to the satisfaction of The Trenton Iron Co., and greatly to the credit of Mr. Reynolds as a designer, who had in the meantime left the Corliss Works and gone to Milwaukee, to take the superintendency of the E. P. Allis Works.

As it will, no doubt, be of interest to know as to some of the details of this engine, it may be said that the principal departure from the standard design was in the width of the steam and exhaust ports: these were twice as wide as usual for a 20-inch diameter of cylinder, and the valve had a correspondingly longer travel. To reduce the momentum of the moving valve gear parts, everything was made as light as possible, and the trip mechanism was all of steel and differed in some respects from the usual construction.

The dash pots were of large diameter, and provided with an adjusting screw to regulate the degree of suction or vacuum, so as to insure closing the valve promptly after release. The frame was of the usual girder pattern then in use at the Corliss Works, and the connecting rod, crosshead, and piston of the usual Corliss pattern. The crank was a disc, with the counterbalance cast in opposite the pin. The piston, however, had only one packing ring, which was about one inch wide, set midway in the width of the piston. The eccentric was unusually large in diameter on account of the long throw required to give the proper travel to the valves.

There was no special provision for lubrication beyond the usual oil cups. It was, however, soon found necessary to make a special cup for the crank pin end of the connecting rod, as no oil cup could be kept filled long enough to run out a heat. Hence, a brass cup or box was made and firmly bolted to the connecting rod strap, with a screw cover that could be bolted down tight, the box was filled with hard, white tallow, and

there was a copper pin one-quarter inch in diameter that fitted loosely in a hole drilled through the bottom of the cup, one end of this pin resting on the crank pin and the other end projecting up into the tallow; there was enough end play to this copper pin to allow it to move up and down about a quarter of an inch at each revolution, and the crank pin heated enough to melt the tallow slowly around the copper pin, which fed it down to the crank pin a little at each turn. The results were good, though the pin, while the engine was running, was quite warm; in fact, too hot to hold one's hand on if touched immediately on stopping the engine after running out a heat. There was no overheating or undue wear on the pin, the surfaces maintaining a high polish.

Indicator diagrams, taken from the engine, show clearly the variations in the loads; it was a continual variation from one extreme to the other between no load and full load while the rolling was in process. As the rod increased in length by repeating into the various passes between the rolls, the work on the engine increased.

In 1891 The Trenton Iron Company found it desirable to roll a considerable quantity of steel rods of greater length than usual, from 250-pound billets, reducing from 4-inch square billets to No. 4½ rods, or 0.23 inch at one heat. This required greater speed and more power, so the steam pressure was increased from 80 pounds to 110 pounds, and the governor pulley on the engine changed to give a speed of 180 revolutions, or 1,260 feet piston speed, and an additional fly-wheel was put on alongside the 10-inch diameter belt fly-wheel, which gave a total fly-wheel weight of 34,000 pounds, and the belt speed with this higher engine speed became 5,653 feet per minute.

We had no trouble from these higher speeds, the engine ran as well as before, and so continued for the next nine years, when a further extension to the capacity of the rolling mill required complete new equipment with two engines of larger size, and in consequence the old engine went where all bad and most good engines go—to the scrap pile.

Current Topics

IN reference to Count Ernst Von Reventlow's article in the Marine Number of CASSIER'S MAGAZINE dealing with German naval policy, it has been assumed that the recent expansion movement in Germany is attributable to England's lead in building large ships. "It was England's *Dreadnoughts,*" *The Philadelphia Record* recently remarked, commenting on Count von Reventlow's article, "that set Germany to building huge fighting machines." The idea that England led the way in construction of ships of huge displacements, which are now becoming general, is an entire misapprehension. The 1904 programme for the British Fleet provided for the construction of two battleships of 16,500 tons, or 150 tons only more than the eight *King Edwards,* which had been provided in earlier years. At that time, the United States in the *Connecticut* class, and the Japanese in the *Katori* and *Kashima,* were actually building battleships of approximately the same dimensions as the *Lord Nelson,* and Russia had under construction at the Baltic and Galerny Island yards at St. Petersburg the two battleships *Imperator Pavil I.* and *Andrei Pervozvannyi,* which were then believed to have a displacement of 16,630 tons, but which it is now known will actually displace 17,200 tons. Russia, consequently, at that period led in displacement, having in hand two ships 700 tons heavier than the *Lord Nelson* and the *Agamemnon* Moreover, in January, 1905, announcement was made of the fact that the Japanese had decided to lay down immediately at Yokosuka a battleship of 19,000 tons, with a speed of 18¼ knots, and an armament of four 12-inch guns, ten 10-inch guns, and twelve quickfirers of 4.7 inches. This Japanese ship is the *Satsuma,* and the original statement of January, 1905, as to its displacement was not quite accurate, as it is now known that she actually displaces 19,350 tons. It is thus evident that long before the *Dreadnought* design appeared other naval Powers, particularly Japan and Russia, had taken the initiative in increasing the size of their vessels. In these circumstances the British Admiralty had no alternative but to make an advance upon the *Lord Nelson* class, and the only problem was how the increased weight should be utilized. It is common knowledge that several alternative designs were prepared, and it was eventually decided to lay down one ship—the *Dreadnought*—with a

displacement of 17,900 tons. Thus the British Admiralty adapted a design representing 1,450 less displacement than in the Japanese battleship, which was laid down early in 1905. The *Dreadnought* was actually commenced in October, and by utilizing the guns and gun mountings intended for other ships, she was completed and in commission within a year and a day. The British authorities did not take the lead, therefore, in ships of huge displacement, but they did show the way in naval design by the adoption of the all-big-gun principle.

There seems no reason to doubt that the British naval authorities are satisfied with the experimental tests which have been made with the new 13.5-inch gun. It has been common knowledge for many months past that the authorities were considering the necessity of adopting a bigger gun rather than follow the lead of other naval authorities who have determined to retain the 12-inch gun as the main armament of their new ships, utilizing increased displacement for a larger number of these pieces, and it has now been definitely announced that the new battleships about to be laid down will be armed with ten 13.5-inch guns. In the new United States battleships, and in those building by Russia, Japan, and Germany, twelve big guns are carried, and the new Brazilian battleships, under construction in England, will also mount a dozen 12-inch guns. The British Admiralty have decided not to adopt this course. The idea is that in British designs the guns shall be so disposed as to enable the whole armament to be brought to bear at almost all angles of fires. This represents a policy of economy in weight and upkeep, and, it is held, enables a vessel to develop a maximum fighting power on a relatively small displacement. British gunnery experts are opposed to a multiplication of big guns, and hence the remarkable difference which is already becoming apparent between the designs of British ships and those of other Powers. This difference of policy is all the more marked between British and American designs, because it is realized that in the United States Navy the gunnery methods approximate most closely to those which have guided the policy of British authorities.

WHY is the full circle of a windmill of the modern type filled with blades? The only space not filled is the central eye and such small space as is represented by the angularity of the blades. The consequence of this may be that the wind deflected from the moving blade will be directed against the next following blade, and will hinder the rotation of the mill. With fewer blades the wind would pass away more freely, and it is likely that there would be more power generated per blade, if, indeed, not actually more power from a mill of a given diameter. The efficiency of the surface would probably be better. An ordinary windmill is simply an impulse turbine without guide blades. The wind advances in a parallel flowing stream and strikes upon the sloping surfaces of the sails or blades. These slip away under the lateral pressure of the air, and the air is deflected in the opposite direction, and can only get away between the blades. Such, at least, appears to be the trend of some recent thought on the question, and there is some reason in it. The old Dutch mills had only four, five or six sails, as a rule. By no means was the full circle covered with sail area. Indeed, a mere fraction was occupied, and much greater sail area could probably have been added. The modern windmill is quite different, and has its whole circle occupied. Are there any tests on record to show what is the effect of this, and is it not quite likely that investigation would lead to changes in design?

WILLIAM H. BRISTOL

A BIOGRAPHICAL SKETCH

THE subject of our sketch this month is an interesting example of the manner in which scientific and academic habits of thought may be combined with practical powers of invention and with successful business capacity.

William Henry Bristol was born in Waterbury, Conn., in 1859, where he received a public school education, and entered into commercial business, continuing in this work until 1880, when he entered the Stevens Institute of Technology, at Hoboken, from which he was graduated in 1884 with the degree of mechanical engineer.

During his junior year he organized the manual instruction department in the Workingman's School in New York, in which he continued to teach until 1886, when he resigned to accept the position of instructor in mathematics at the Stevens Institute. Two years later he was made assistant professor, and in 1899 he became professor of mathematics in the institute. This connection with Stevens Institute continued until 1907, since which time the pressure of business affairs caused him to devote only a portion of his time to instruction, and at the present time he is special lecturer in applied mechanics in the institute.

Among the mechanical inventions developed by Professor Bristol a number have attained wide application and success. Prominent among these may be mentioned the recording pressure gauges, for use with steam, air, gas, etc.

These gauges involve the use of a flattened helical tube, with attached arm, carrying a pen making a record upon a revolving disc, without involving the use of any intermediate multiplying mechanism. A similar arrangement, in connection with a system of corrugated diaphragms, is used for recording very low pressures, such as are encountered with the flow of illuminating gas, etc.

By applying analagous principles to the measurement of temperatures, Professor Bristol has produced recording thermometers of a wide range of usefulness, the expansion of liquids or gases under the changes of temperature acting upon the recorder. With these instruments industrial temperature measurements as high as 800 degrees F. are accurately and continuously recorded.

In measuring higher temperatures, Professor Bristol has invented an important improvement upon the expensive and delicate platinum-rhodium pyrometer, by substituting a low-resistance, inexpensive special-alloy thermo-electric couple, having a high electro-motive force, thus producing accurate indicating and recording pyrometers for high temperatures. These instruments have found very extensive use in the arts, and thousands of them are daily employed in many varied industries.

All these instruments have been continually improved in the light of the experience which has been gained in their manufacture and use. Thus there have been designed recording voltmeters, in which the scale begins

at 220 volts, and having the total range covering but 10 volts, so that variations as small as one-twentieth of a volt may be easily read. In like manner recording pressure gauges have been made for total ranges as low as 0.6 of an inch head of water, thus adapting them for recording draft-pressures in chimney and boiler flues, and similar work.

In the measurement of the velocity of flowing water or gases by means of the Venturi meter or the Pitot tube, it is desirable to record the differences between two simultaneous pressures continuously, and for this purpose, Professor Bristol has devised a modification of the recording pressure gauge, by means of which the differences between the two pressures are recorded upon one chart.

In some cases it is desirable that the recording device shall be situated at a distance from the point of application, and several of the instruments devised by Professor Bristol are thus arranged. Among these may be noted one for recording temperatures of comparatively low ranges, as occurring in refrigerating plants, cold-storage warehouses, etc., a distinctly modern and original apparatus.

Another invention of Professor Bristol's is an ingenious form of sheet-steel belt-lacing, which has found extensive application and is an article of commercial usefulness.

Professor Bristol began the development of his various inventions when he was yet a professor at the Stevens Institute of Technology, and as long ago as 1889 he organized the Bristol Company, of Waterbury, Conn., for the manufacture and development of his mechanical ideas. As a result of the production of these devices the business steadily advanced, and at the World's Fair in Chicago, in 1893, the company was awarded a medal and diploma both for the recording instruments and the steel belt lacing. On March 5, 1890, the Committee on Science and the Arts, of the Franklin Institute, awarded to Professor Bristol the John Scott Legacy and premium for the sinuous-tube recording pressure gauge, and on January 3, 1894, the Franklin Institute also awarded him the Edward Longstreth medal of merit for his diaphragm gauge for extremely low pressures. Professor Bristol's instruments were exhibited at the Paris Exposition of 1900, and received a silver medal.

With the development of the business of the Bristol Company the demands upon the time of Professor Bristol became so great that he found it necessary to withdraw from much of the active work of teaching, and, as already mentioned, his work at Stevens Institute is now limited to that of special lecturer in applied mechanics, his time being otherwise devoted to invention and improvement in connection with the work of the company. The list of his patents now totals about fifty, and is continually increasing.

Professor Bristol is a member of the American Society of Mechanical Engineers; Fellow of the American Association for the Advancement of Science; Member of the American Institute of Electrical Engineers; and Member of the American Electrochemical Society.

MELVILLE W. MIX

PRESIDENT DODGE MANUFACTURING COMPANY

See page 480.

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SIBERIA

ITS INDUSTRIAL AND COMMERCIAL RESOURCES

By Henry G. Read, M. Inst. M. E.

In taking stock of the natural resources of various parts of the world, we believe that the Eastern portion of the Russian Empire demands especial attention at the present time, not only because of its important connection with the development of the Far East, but also because of its inherent importance. Siberia offers a great market to the manufacturers of Europe and America, and in return it has to exchange its own supply of raw materials, and the view which Mr. Read presents cannot fail to be of the utmost interest to engineers and business men alike.—THE EDITOR.

JUNKS ON THE SUNGARI

ALTHOUGH there is evidence of trading having taken place between the inhabitants of Eastern Russia with those of Siberia so far back as the eleventh century of our era, the first mention of Siberia in the historical records of Russia occurs, apparently, about the year 1407, and from that date onward Russia appears to have been in continual conflict with the semi-barbarous peoples inhabiting Siberia. Although encountering many reverses, Russia succeeded in getting continually a firmer grip on the territory, advancing eastward after each serious conflict until, in the treaty made with China in 1858, she secured her right to the territory on the left bank of the river Amur. After this treaty Russia speedily followed up the advantage which she had gained until she reached the coast of the Pacific Ocean—the goal which she had ever had in view, and for which she had persistently fought for hundreds of years against almost insuperable obstacles.

In spite of the fact that during the past two hundred years there have been numerous scientific and exploring expeditions to various parts of Siberia, the country was almost unknown to every one except those engaged in the administrative work of government; and even now, after the completion of the Trans-Siberian Railway, there are thousands of square miles in various districts about which little is known. This is hardly

THE GREAT GATEWAY AT TSITSIKAR

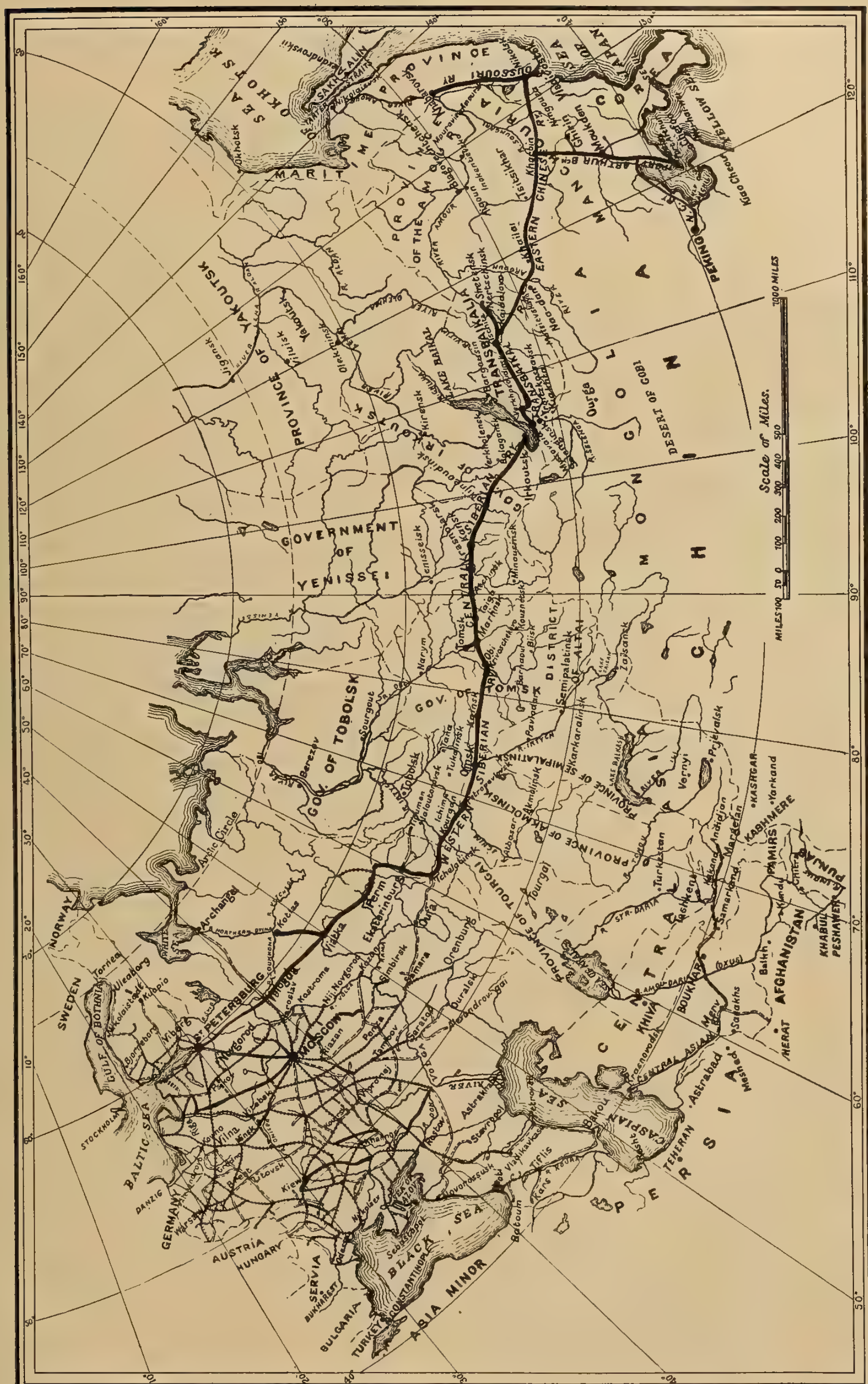
a matter for wonder when it is remembered that the area of Siberia constitutes about one-thirteenth of the entire land surface of the earth, being larger than the entire area of Europe. Although immense strides have been made during the past ten years in the opening up of the country to colonization, accompanied with the advent of various exploring parties into the interior, it must still be many years before the whole region is fully investigated and its economic value from all points thoroughly understood and appreciated.

In order to give but a slight idea of the tremendous future which lies before Siberia and the high degree of prosperity to which it must eventually attain, it is necessary to say a few words about the general character of the whole region from a physical point of view.

On the north the entire coast is washed by the Arctic Ocean, studded with bays and inlets, forming the mouths of the many large navigable rivers, these latter, however, being open to navigation at the coast only about two months in the year. On the south the Chinese Empire extends from Bokhara on the southwest corner eastward to the Pacific Ocean, while on the west the boundary is the Ural Mountains, running directly across from north to south, dividing Siberia from Europe. On the east and northeast it is bounded by the Pacific Ocean.

The rivers watering this immense area are numerous and important. With one notable exception, these all run from south to north and empty into the Arctic Ocean. The chief of these rivers may be placed in the following order, considering their size and length:

The Lena, which runs through Eastern Siberia, has a length of three thousand miles, taking its rise to the west of the southern end of Lake Baikal, and running east to Yakutsk and thence almost due north to the Arctic Ocean. The principal tributaries of the Lena—immense waterways in themselves—are, on the right bank, the Aldan, with a length of 1,320 miles; the Vitim, with a similar length, and the Olekma, with a length of 660 miles. On the left bank there is but one large tributary, the Vilmi, with a length of 660 miles. The river next in importance to the Lena is the Yenesei, which



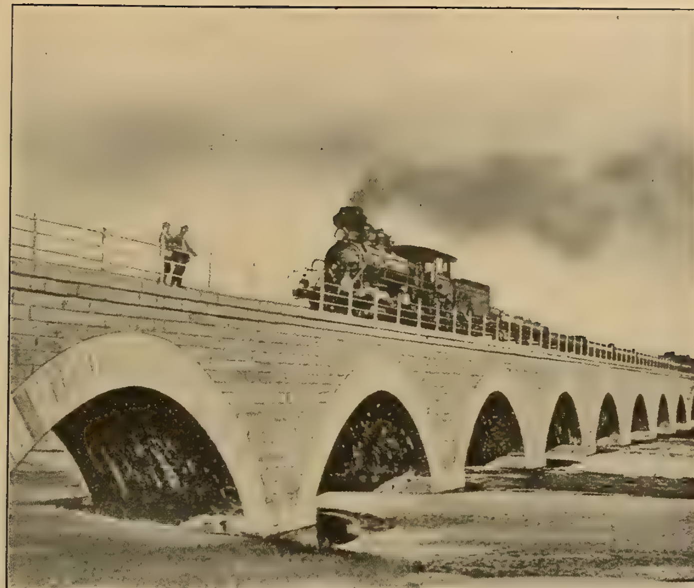
MAP OF THE SIBERIAN RAILWAY AND ITS EUROPEAN CONNECTIONS

flows through Central Siberia, having its source in a small lake in Chinese territory in the south, and with a length of 2,650 miles, running almost due north to the Arctic Ocean. Its chief tributaries on its right bank are the Angara, with a length of 1,060 miles; the Middle Tunguska, with a length of 990 miles, and the Lower Tunguska, with a length of 2,200 miles. The third river in importance is the Obi, which, with its prolongation, the Biya, has its source in Lake Telenkoi, and flows northwards and westwards for some 2,100 miles to the Obskaya inlet of the Arctic. Its main tributaries on the right bank are the Tom, with a length of 460 miles; the Tchulim, 660 miles long, and the Vax, of a similar length. The tributaries of the Obi on the left bank are the Irtish, with a length of 2,450 miles, and the Vasugan, 530 miles long.

All the foregoing streams are what may be termed rivers of the first order; that is, they are navigable for large, shallow-draught craft for the greater part of their length. There are also a number of rivers of the second order, their commercial importance being less. Among these may be noted the Taz, with a length of about 700 miles; the Hartanga, 460 miles long; the Olenski, extending for 1,100 miles; the Yarna, 990 miles; the Indigirka, 900 miles, and the Kolima, 990 miles, all of these flowing into the Arctic Ocean.

A WAY STATION ON THE SIBERIAN RAILWAY

The one river of importance which does not run into the Arctic Ocean is the Amur, with its prolongations, the Shilka and the Argun, which rises in China, far to the south of Lake Baikal, flows eastward to Khabarovsk, and thence northward to the, at present, free port of entry, Nikolayevsk, on the Bay of Okhotsk, and thus delivers its waters into the Pacific. From Lake Dalai northwards to Khabarovsk this river forms



A VIADUCT ON THE WESTERN SIBERIAN RAILWAY

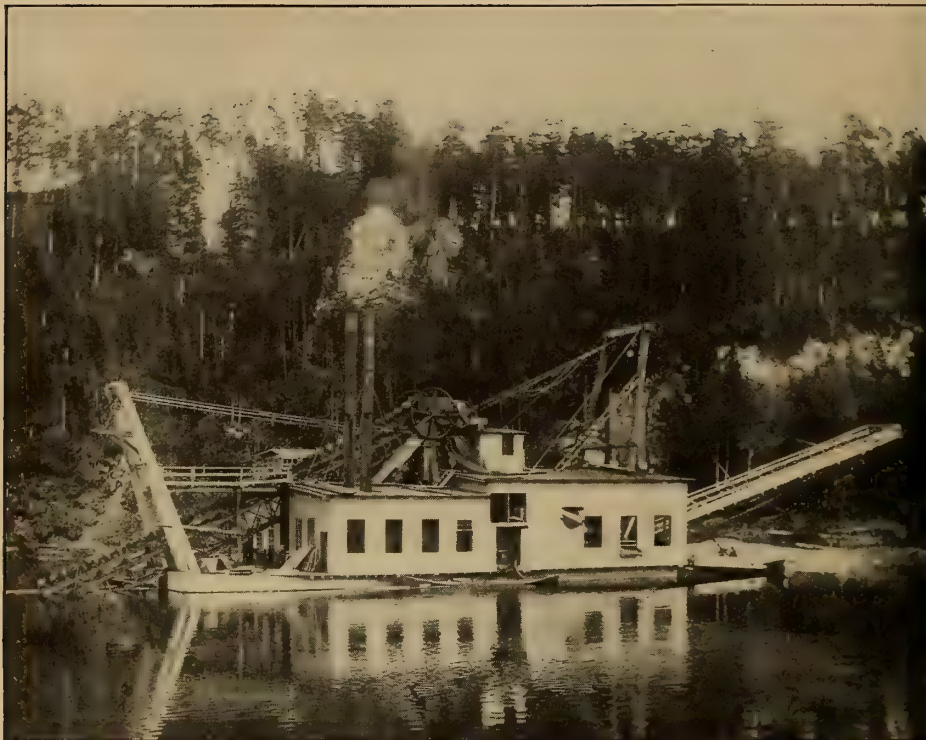
a portion of the frontier between Siberia and China. The length of the Amur is about 2,000 miles; its tributaries on the right bank are the Ussuri, Sungari, Uda, Yama, Pendjima, Kamchatka and Anadir, and on the left bank the Zeya and Bureya. All of these tributaries are of great length and are navigable for a considerable portion of their courses for shallow-draught boats.

The most important river flowing through the steppe region of Western Siberia is the Tobol, which, with its prolongation, the Ishim, has a length of about 1,000 miles, and flows into the Irtish on its left bank. The Tobol is navigable for large boats from its tributary, the Tura, situated a little to the east of the important trading town of Tyumen.

Siberia is studded with lakes in almost every district, some of them being of very large area. The principal of these is the well-known Lake Baikal, which has a length from north to south of about 400 miles and a width varying from 20 to 33 miles. This lake, or inland sea, is surrounded by precipitous mountains, and has a depth of 4,900 feet; it is probably formed of a series of craters of former volcanoes. Lake Balkash, in the province of Semipalatinsk, has a length of more than 400 miles and a width of 10 to 30 miles. Lake Zaisan, which is rich in fish, has a length of 75 miles, and is from 10 to 20 miles wide; the steppe Lake Chani is also filled with fish, and is about 50 miles long and between 30 to 40 miles in width. Lake Chagli, in the province of Akmolinsk, is a bitter salt lake; and there are many others, both salt and fresh, throughout Siberia.

The mountainous regions of Si-

A CUTTING ON THE SIBERIAN RAILWAY



A BUCYRUS GOLD DREDGE IN THE URAL MOUNTAINS

beria include the Urals, in the west, and Altai range, in the south. These latter form part of a chain running from Bokhara, in the southwest, passing eastwards and curving northwards around Lake Baikal and thence in an easterly direction, branching to the northwards to the coast and southwards through Manchuria to the end of the Liao-Tung peninsula.

The whole of this immense mountain range is rich in every description of mineral wealth, even as are the Urals, in the west. The riches of the Altai range are known and realized by but few, but it is probable that its mineral wealth far exceeds that of any known region of the surface of the earth. In addition to its mineral deposits, the enormous tracts of forest must be taken into account, since these must play an important rôle in the development of the mines.

The foregoing particulars, limited, as they are, for lack of space, are necessary in order to enable the reader to appreciate the enormous importance of the Trans-Siberian Railway. An examination of the map will reveal the relation of the physical character of the land to the railway.

The main Siberian Trunk Line commences at the large town of Tscheliabinsk, on the eastern slope of the Ural Mountains, where the junction with the main European Russian Line is made. This latter railway crosses the Volga at Samara, running through Ufa and over the Urals to this junction. There is also a second line from European Russia, running due east from St. Petersburg through Vologda, Viatka and Parm to the northern Urals, thence turning southwards through the Urals to the important centre of Ekaterinburg and passing on southwards until it makes a junction with the Siberian line at Tscheliabinsk.

From this junction the Siberian Railway starts running almost due east, passing either through or in the immediate neighbourhood of many of the chief trading centres of Siberia, amongst others the towns, in the following order: Kurgan, Petropavlovsk, Omsk, Kainsk, Kolivan, Tomsk, Marinsk, Achinsk, Krasnoyarsk, Kansk, Nishnidvinsk, Balagansk, to Irkutsk, at the southern end of Lake Baikal.

FLOUR MILLS AT NIKOLSK, ON THE SIBERIAN RAILWAY

Of these towns, the most important are Tscheliabinsk, Omsk, Tomsk and Irkutsk.

From Irkutsk two routes are available: the trains may be carried across the southern end of Lake Baikal by ferry, a distance of 68 versts (45 miles), to the station of Misov, or they may enter the second section of the Siberian Railway at Irkutsk, known as the Circum-Baikalien Railway, passing around the southern end of Lake Baikal; also to the station of Misov, and thence through Chita to Karimskoi, where the Baikal Railway is divided, one branch going eastward through Stretensk to the banks of the river Shilka, where it at present terminates. The other branch runs northeast from the junction Karimskoi to the Chinese frontier, the station on the Russian side being Matsievskaya, or, as now called, "Siberia," while that on the Chinese side is called Nao-dan, or "Manchuria."

Here begins the third section of the railway, known under the name of the Eastern Chinese Railway, which runs on through Hailar, Tsitsikar and Kharbin to the frontier station at Grodekovo. From thence the fourth section, called the Ussuriski Railway, runs on to Vladivostock, whence a branch extends northward to Khabarovsk; while another branch, forming the fifth section of the Siberian Railway, runs from Kharbin through Manchuria southward to the ports of Dalny and Port Arthur. It will thus be seen that the Siberian Railway consists of five sections, each of which has a

RAILWAY BRIDGE OVER THE SUNGARI RIVER

separate denomination and administration, all of which are under the central control of the Russian Government, with the exception of the branch running southward through Manchuria to Port Arthur.

The Siberian Railway crosses 28 large rivers, involving a total of 28,000 feet of bridge-girder work. The chief of these, with their lengths, are as follows: Over the Tobol, at Kurgan, 1,400 feet; over the Irtish, at Omsk, 2,700 feet; over the Obi, 2,520 feet; over the Tom, 1,680 feet; over the Yenesei, at Krasnoyarsk, 2,940 feet; over the Selenga, 1,792 feet, and over the Hori, 1,400 feet.

It is thus apparent that the Siberian Railway not only passes through all the principal trading centres of the country from west to east, but also crosses all the great navigable waterways which flow from south to north, and which carry large amounts of merchandise and act as feeders and distributors of goods in both directions. It is probable that in no other portion of the world, not excepting the United States and Canada, is there to be found a railway so favourably situated with respect to navigable rivers. Thus everything is available for the development of the great natural resources of this immense section of the world's surface, and all that is necessary is the commercial energy and capital to render it a source of new wealth.

At the present time a number of new railway projects are under consideration. Thus, the double-tracking of the main trunk line has been determined, and work upon this has practically been commenced. It has also been decided to construct a line to join the main trunk line along the left bank of the Amur, this running from a junction just east of Chita to Khabarovsk, and the survey is now in progress. This railway will give a second route to the port of Vladivostock, and, although its commercial value does not appear to be as great as some others which are projected in Central and Western Siberia, yet, from a strategical point of view, it is of the first importance to Russia in connection with the maintenance of her hold on Eastern Siberia and its ports. This connection being secured, and the main trunk line of the Siberian Railway double-tracked, Russia will be at liberty to throw her energy into the construction of new branch lines to link important outlying towns with the main-line railway.

A new line of railway is now also projected to run from Chita north and east to Kamchatka. This line will probably be constructed by a private company, backed by French capital, as soon as the survey is completed and the necessary arrangements with the government are concluded. The commercial importance of this line does not yet appear, and it is difficult to form an opinion concerning it.

Another line is projected to the south of Tomsk, in Central Siberia, connecting the trading town of Bar-

naul with the main trunk line by way of Nerchinsk. As now planned, this will be a short line; but at a later date it will form a link with a line from the south.

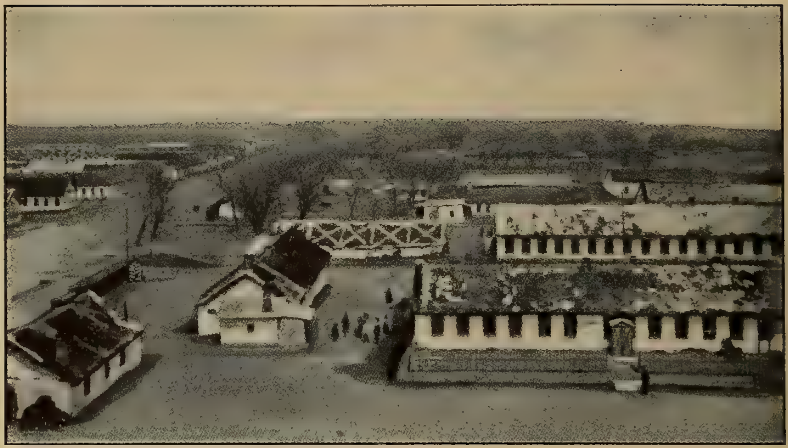
At the present time a survey is being made by government engineers for a continuation of the Ekaterinburg-Tiumen line to a junction with the main trunk line, either at the town of Kurgan or of Omsk. Probably the selected route will be by way of Tiumen-Omsk, which would enable this line subsequently to be extended south, through the large town of Pavlodar, to Semipalatinsk, running for the entire route through an easy, fertile and well-populated district. The route by Tiumen-Kurgan would be of less importance if extended, while Kurgan itself is by no means a place of as much commercial importance as Omsk.

There is also a line projected under the auspices of the Uralsk-Riazan Railway Company to run from Tscheliabinsk through Troitsk, Kustanai, Atbasar and the Akmolinsk-Karagand coal mines to Semipalatinsk. This line would be mainly for the benefit of the coal mining company, the Spassky copper mines, the Troitsk gold mines, and other local industries. It would run through a difficult country, and the capital of £1,500,000 which it is proposed to raise would scarcely be sufficient to build the line in a substantial manner and leave a working capital.

PANORAMA OF VLADIVOSTOCK

Under these conditions it is probable that the Russian Government will enter into no financial guarantees in connection with it, and it is very doubtful if it will be extended through the mountains to Semipalatinsk for a long time.

Another project—which, however, is not expected to take definite form for a few years—is to connect the Tashkent Railway line by a continuance across the southern portion of Siberia to a junction at Semipalatinsk, eventually extending it from thence in a northeasterly direction to



A BIT OF THE OLD TOWN OF KHARBIN

make a junction at Barnaul with the short line already mentioned. This would make a noteworthy line in many respects, as it would connect up the rich mining districts in the south and pass through Semipalatinsk to a fertile country beyond, which is now being taken up for settlement.

Even these lines must be considered only as a beginning, and, when the vast extent of Siberia is remembered, it will be realized that many such feeders to the main trunk line will be required, and that hereafter a third and fourth track will have to be added to meet the traffic yet to be created.

The influx of immigrants to Siberia is now at the rate of 500,000 yearly, and, as this feature continues to show an increase, it will doubtless become necessary to construct more new railways. These would

THE RAILWAY STATION AT KHARBIN

doubtless have been taken in hand before this but that financial questions had to be considered. The government, however, is now expressing its willingness to grant concessions to private companies to construct and work such lines in Siberia, and doubtless many of them will be taken up and completed by foreign capitalists. Such lines will be of 150 to 600 miles in length, and those running through certain districts and connecting important trading centres will undoubtedly pay from the very start, if placed in the administration of practical business men.

It has naturally been the desire of the Russian Government to retain the construction and operation of all the railways in its own hands; but the necessity and importance for the immediate development of communication and transport throughout Siberia have been recognized, both because of the continual stream of immigrants settling in the country, serving as agriculturalists and miners, and also because of the strategic value of the lines. The government itself is fully occupied with the immediate work of the construction of the Amur line and the double-tracking of the main trunk line of the Siberian Railway, and hence if private capital is permitted to undertake the branch lines everyone will gain thereby.

The double-tracking of the main trunk line of the Siberian Railway is of the utmost importance to the government, not only for strategical reasons, but also for the commercial development of the thousands of commercial people engaged in the large towns served by the railroad. These are all handicapped by the single line of the railway as it exists at present, the delays in shipments being a continual source of worry, annoyance and financial loss to all concerned. It is to be hoped that this important work will be pushed forward to a rapid completion and a more effective control over its operation instituted. This will probably be the case, as an inquiry is being held at the present time into the administration of the line, by which recent irregularities will doubtless be corrected.

THE HARBOUR OF VLADIVOSTOCK, THE TERMINUS OF THE SIBERIAN RAILWAY

HOTEL AT THE KHARBIN RAILWAY STATION

It is to be hoped that the new lines will be brought well into the centres of the towns, instead of running to one side, as has heretofore been the custom. It has been stated that the practice of keeping the railways out of the towns has been on account of the danger of fire, but this risk might certainly be prevented by proper construction and precautions. The loss to the railways and to the towns by reason of the distance of the lines from the immediate proximity of the latter is certainly great, and it is most desirable that this feature should receive consideration in future construction and location.

It is difficult to estimate the influence of the Siberian Railway upon the country from an economic point of view. It is certain, however, that it has been the cause of an immense influx of population to all the trading centres and settlements. During the war there was a boom in everything, and trade was abnormally brisk; but after the war there was a reaction, and everything fell flat. Although this latter state of things continues, there are indications that this is passing and that trade will not only become normal, but that a rapid increase will follow. There also appears to be a foreign interest reviving in Siberian matters, although it will be long before the false impressions created by the Siberian mining "boom" are forgotten. Still, it must be remembered that one rainy day does not make a wet summer, and when one realizes the vast extent of Siberia it is foolish to condemn the whole country and its value for investment because of a disaster in one corner of it.

In Siberia we have what is practically a new country, larger than all Europe put together, watered everywhere by immense rivers and crossed through its centre by a trunk line of railway, with mineral riches untold, with large and thriving towns at intervals from one end to the other, many of them with populations of more than 100,000, and with an immigration of more than 500,000 souls a year. It is a land with a soil of wonderful fertility, exporting millions of poods of agricultural produce annually, an agriculture which is increasing rapidly every year.

It has, however, no manufactures to speak of, considering its size; a few spinning mills and weaving

sheds, and hardly any engineering works, shipbuilding yards, leather works, etc., worthy of the name, and but few of its mines worked in an up-to-date manner.

In Siberia manufactories are needed in all the large trading centres, and, if run on modern commercial lines, they would pav handsomely. At the present time there are hundreds of little works scattered about at long distances apart, many of them run by horse-power and others without any power at all, but with everything done by hand; most of them are worked with the crudest appliances and in the most primitive manner. They are mostly in the ownership of people of limited education and small capital, working almost from hand to mouth, so that they are unable to make proper extensions to their business, and are thus kept within a narrow trading limit.

The following figures will give some idea of the manner in which the vast territory of Siberia is provided with works and manufactories. These figures, however, must not be taken as exact, as changes are continually being made; but they may be considered as fairly representing things as they were at the close of the year 1907:

Province.	No. of Works.	No. of Workmen.	Turnover (Roubles).
Akmolinsk	925	3,900	4,100,000
Semipalatinsk	67	800	2,306,000
Tobolsk	4,500	11,000	16,737,000
Tomsk	9,000	19,000	6,000,000
Yenesei	849	3,000	6,000,000
Irkutsk	90	2,500	2,000,000
Baikal	180	2,500	2,976,000
Amur	75	1,000	3,132,000
Yarkutsk	100	200	58,000
Primorskaya	933	2,500	3,000,000
Total	16,719	46,400	46,309,000

Here we have a total of fewer than 17,000 undertakings, which make a yearly turnover of a little less than £5,000,000, employing about 46,000 hands, giving a production per man per year of about 1,000 roubles, or about £95 per year (less than $500).

The significance of the above figures will be apparent if we take the corresponding data either for Europe or for the United States, each smaller in area than Siberia; even if we consider that one-third or possibly one-half of the country is uninhabitable, which is reallv not the case, the significance of the figures remains.

In order to analyze the data given in the preceding table, we give the following distribution:

Class of Manufacture.	Number of Works.	Turnover (Roubles).
Brickworks	953	3,504,000
Flour mills	8,296	6,833,200
Sawmills	30	1,100,000
Oil mills, inclusive of butter works and cheese production.	2,037	7,535,000
Leather works	731	1,637,000
Engineering works	19	1,000,000
Shipbuilding wharfs	7	410,000
Blacksmith and wheelwrights.	1,275	414,000
Smelting works	1	235,000
Breweries and mineral waters.	87	1,205,000
Soap, tallow and candle works	437	1,846,000
Spirit distilleries and yeast	55	5,920,000
Salt and soda works	33	210,000
Cement and lime works	10	690,000
Wool-combing and washing	19	465,000
Textiles, rope and twine	34	644,000
Felt goods, boots and fur clothing	190	1,414,000
Total	14,214	35,062,200
Leaving a balance of	2,505	11,246,800
Total as already given in first table	16,719	46,309,000

The balance comprises a host of small concerns, such as tar distilleries, fitting shops without power, joineries of the same small kind, glue boilers, glass works, tobacco works, porcelain, stoneware and glazed ware, etc., etc., having but few employees, but turning out a large sum in the aggregate, nearly one-fourth the total product per annum.

One of the first things which will strike the reader is the insignificant position occupied by the engineering works of any importance. This state of affairs is almost incomprehensible when one considers the immense area of the country, its inexhaustible riches in all kinds of minerals, and its great waterways. Practically all machinery, as well as all products of iron and steel, such as bars, plates, structural material and similar goods, are imported into Siberia from Russia and abroad, and transported over thousands of miles of railway, sea and river to their ultimate destinations. Much of this material, although not the largest proportion of iron and steel products, comes from the Ural district. Although the

THE FERRY AT NIKOLSK

material is generally of good quality, the works of this district are so deficient in modern machinery and so handicapped by antiquated methods that orders placed with them are continual sources of trouble and delay, and serious mistakes often occur.

Many of the works in the Ural district belong to the Russian Government; but in spite of the advantages of their position with respect to supplies of all the necessary raw materials, with plenty of cheap labour and freedom from financial anxieties, these establishments, in many instances, do not pay their way. If such works were operated upon modern business methods they would be capable of indefinite extension, and might well supply all the trade requirements of Siberia, to the exclusion of all iron and steel products now imported from Russia and from abroad.

The results of many of these works have been so unsatisfactory that the Russian Government has decided to hand certain of them over to private companies. Although the conditions upon which this is to be done have not yet been made public, there is no doubt that there is here an opportunity for foreign capitalists, who, if they would go to work in the right manner, might soon turn these important works to a very different account and make them pay very handsomely.

The number of joint-stock companies operating in Siberia is probably not more than one hundred, all told, the exact figures being very difficult to obtain, as they comprise Siberian, Russian and foreign concerns, the names of which, when translated into different languages, render it very difficult to identify them accurately.

The mining concerns of all classes, both large and small, may be given roughly as follows:

Coal	65
Copper	40
Manganese	3
Iron	12
Fire clay	25
Quarries	100
Salt, chiefly from salt lakes	21
Graphite	2
Gold	700

The number of these is continually varying and generally increasing.

The number of gold mining concerns includes both those which are being worked with some regard to modern methods and also claims worked in the most primitive and inefficient manner. Each year fresh discoveries of gold are recorded, some of these being important and some less so. A large number of claims are worked for a month or two only each year, simply to maintain a hold on the claims and provide a bare sustenance for the holders until they can scrape together sufficient capital to work the property in a more rational manner.

The foregoing tables and data will indicate to the practical business man the general inefficiency and primitive working methods in vogue generally throughout Siberia. Such men will also recognize that the majority of

SIBERIAN PEASANTS AT THE NIKOLSK RAILWAY STATION

these businesses must be paying their way even under such defects and drawbacks, otherwise they could not long exist. At the same time, the capital available is generally so limited in amount that nothing is left for extensions. In many of the works the equipment is antiquated, while if new capital was introduced and modern machinery installed an excellent return could be made on the whole capital invested.

It is impossible, within the limitations of a single magazine article, to go into all the intricacies presented by such a large and important question as the economics of Siberian manufacturing, or even to tabulate the different industries according to size, output, labour employment and locality. Even if this were done, however, it would show that the figures already given would not be materially altered and that in nearly all industries the primitive methods of working prevail. It is this fact which renders the opportunities for capital in Siberia so well worth consideration in nearly every department of industry, without respect to any particular line of manufacture.

Referring to the gold mining industry in Siberia, a line of work assumed to be largely speculative throughout the entire world, there are but few of the claims which are being worked on up-to-date methods, although some of the placers are employing the latest designs of gold dredges. In many instances, however, the most primitive and wasteful methods are employed, the coarse gold only being won, while sometimes as much as 50 per cent. of all the gold contained in the washed ore or sand is lost. Many causes doubtless contribute to this state of affairs, some of them local and climatic; but the principal reason, doubtless, is the want of capital and the lack of proper knowledge on the part of the owners as to the best methods of working their claims. The majority of them have neither the means nor the experience to bring their opportunities to the notice of those who have the capital and the ability.

A STATION ON THE SOUTHERN RAILWAY

There are scores of almost worthless properties, as in every district, but there are also many that are of very great value; but even these are often worked in a rough-and-ready manner by their owners, so that just about enough is made to enable both ends to meet, leaving little or nothing over for proper surveys, exploration, analyses, etc., to say nothing of the cost of distant journeys to bring the results of the claims to people who might be willing to invest.

Other claims are owned by wealthy

AN AMERICAN GOLD DREDGE IN SIBERIA DURING THE CEREMONY OF BLESSING BY A PRIEST OF THE GREEK CHURCH

people living in St. Petersburg or Moscow, who probably give but little attention to the detailed operation of their properties, and are disinclined to spend any money in improvements. Such owners are generally satisfied so long as the sum they expect from the property is regularly forwarded, and there is doubtless a great leakage from many such mines. If these operations were carried on according to modern business methods, under competent and reliable supervision, with improved appliances and energetic and efficient labour management, the output might be enormously increased and the operating costs lowered. It is impossible to tell how long the present conditions will continue, but it is high time that the mining industry in Siberia was taken seriously and put upon a firm basis by rational exploitation.

It is often pleaded that the Russian Government places all manner of obstacles in the way of manufactures and mining development, but this is all nonsense. On the contrary, the government desires to see commercial enterprises started in Siberia, and is ever ready to encourage *bona fide* undertakings. Naturally, the general provisions of the law of the land have to be observed, just as is the case in every country; and these laws are not more onerous than those of Germany, England or America, but probably are less so. The initial formalities are somewhat severe; but if taken in hand in the proper manner there is no trouble in getting through them, after which the business can be started and conducted without fear of interruption. The misrepresentations so often met in the newspapers as to the hostility of the Russian Government to commercial enterprises are often the result of the efforts of interested parties who do not wish to see competition increased, and much mischief has been due to such unauthorized opposition.

SIBERIAN PEASANTS AT NIKOLSK

Labour is abundant and cheap in Siberia; but the cost of living is higher than it should be, mainly because of the lack of local manufactories to compete with imported goods. Transport is somewhat slow, but this will be remedied as soon as the double-tracking of the Siberian Railway is completed. The railway is there, and the waterways are there, while transport by sledge is swift and easy in the frozen season. New railways have been sanctioned and others are projected, and those who first establish manufactories in Siberia will be the first to benefit bv the developments. Unfortunately for these developments, it is vastly to the interests of the large exporters to Siberia to make it appear a bad country for new enterprises, since any such improvements will make it necessary for them also to build works there or lose the bulk of their trade. It is, therefore, much easier for them to endeavour to discourage investment and the development of local industries than to raise capital and acquire manufacturing experience to do the work themselves. It is time, however, that the true situation of affairs in Siberia was made known and its opportunities shown. The country is only seven or eight days away from London, and money invested in industrial development of properly organized enterprises can be made at least as safe as in undertakings situated several weeks away from the financial centre.

It is becoming apparent that more interest is being taken at large in Siberia and its possibilities. Now and again mysterious visitors come and go, all making inquiries, but the majority departing with utterly false impressions. Such visitors are generally accompanied by carefully instructed guides, provided by people in Russia to whom they have come with instructions, and by whom they are filled with knowledge of a sort which they can hardly understand, or which is wholly useless. Many such visitors to Siberia may be found in London, and the authoritative opinions which they offer, based upon their experience on the spot, should be received with the reservation that it is altogether possible that they have been on the wrong spot.

The few visitors who come to Siberia unattended, without introductions, and who move quietly about, coming into direct contact with the people and business conditions of the country, these few see and learn more in a few days than the man with the guide sees in months. Information thus obtained by unassisted personal investigation gives an entirely different picture of the country than can be obtained through the aid of interested individuals, and enables a true insight into the actual needs of Siberia and its opportunities for new enterprises to be secured.

METEOROLOGICAL STATION AT KHARBIN

VIEW LOOKING NORTH OVER VLADIVOSTOCK

Before the completion of the Siberian Railway there was some excuse for considering the country as remote and difficult of access, but since the opening of the line no such considerations obtain; the country is as accessible as America, and the transportation question is already settled to a large extent.

While openings exist for all sorts of commercial enterprises in the large towns and well-populated districts of Siberia, it should be remembered that any new undertakings ought to be established on rational lines—not started in a grandiose way, but so arranged that they may be extended as the growth of the trade demands, without involving stoppage or delays. Warning should be taken from the experience of those concerns which have put all their available funds into bricks, mortar and plant, leaving nothing for working capital, and compelling the burden of mortgages to be placed upon the enterprises at the outset. There are many works in Russia, however, which have been commenced in a modest way, extending their buildings and plant year by year out of their revenue, and are to-day powerful undertakings, employing thousands of men. Such concerns have little or no indebtedness, and are paying dividends instead of interest, and will continue prosperous so long as wise management continues. Similar enterprises, conducted on similar lines, will meet with like success in Siberia, and probably be even more profitable with the development of a new country.

The chief drawback, of course, is the language; but with ordinary intelligence and business acuteness that is overcome in far less time than most people would imagine, and in any case it hinders business very little provided the methods of working are right; the language is largely phonetic, and is much less difficult to learn than Hindustanee or Chinese.

The climate of Siberia should prove very little drawback. The winters are colder than English winters; but it is a dry cold, not felt as in countries where the moist atmosphere, standing a little above zero, penetrates to the bone. For the greater part of the winter the sky is unclouded and sunny and the air no

colder than in Canada or many parts of the United States. The occasional severe snowstorms, with wind, seldom last for more than a day or two, and then all is calm for weeks together. The air is bracing and invigorating, while the summers are hot, and there is often much dust; but that exists elsewhere, and is counted no drawback to business. The temperature naturally varies in different districts; along the line of the Siberian Railway and to the south of it there is nothing in the climate that need trouble a healthy man.

One feature in Siberian trading and manufacturing, common also to European Russia, demands attention; it is the "Artel" system. The Artels are combinations of workmen representing individual occupations and handicrafts, and are especially prevalent among the village communities. They are really associations worked on the communistic principle, the work, of whatever nature, being parceled out among the members, together with the material supplied therefor, the profits on the work being divided amongst the members of the Artel in strict accordance with the rules governing its procedure. Many of these Artels are also in the nature of fidelity guarantee associations, providing from their membership candidates for positions of trust for banks, commercial and manufacturing concerns, and furnishing bonds for their members as surety for their honesty. The trading Artels comprise such handicrafts as bricklayers, carpenters, joiners, blacksmiths, etc., and, with the exception of the outdoor work, most of the members carry on their business in their own cottages, much of the work being done in the winter time by the peasants and others during the season when they cannot cultivate the land. Since the needs of the workers are small, the remuneration is not high. For example, there is a form of winnowing machine used by the farmers to separate the corn from the chaff and straw after threshing. These machines are very similar to a well-known English type of machine, but

ON THE SIBERIAN RAILWAY AT THE FOOT OF THE KHINGAN MOUNTAINS

are much larger, and are sold in thousands, being manufactured in Samara and along the Volga, and found in all the dealers' stores from Odessa, in Southern Russia, to Vladivostock, at the extreme east of Siberia on the Pacific. These winnowers are lightly but strongly built, and consist of a light frame, with the enclosing sides made of very thin sheet iron; they differ slightly in design and construction, according to the district from which they come, but they are thoroughly serviceable and do their work in a satisfactory manner, all attempts to improve them having failed. These machines are sold to the selling agents at from 17 to 20 roubles, and are sold at retail as low as 25 roubles each, the price varying according to the district and the cost of transportation to the selling point. This excessively low price is due to the system followed out by the Artels. Each man has a special part of the machine to make, this being formed to a templet and made in lots by the hundred. These parts are brought together and assembled by another group of workmen specialized in this department of the work. This is precisely the system adopted in every workshop in America and Europe; but it has been in vogue in Russia long before it was thought of elsewhere, the only difference being in the rough-looking hand tools and in the fact that the peasant, with his crude implement, can produce the articles for about one-half to one-third the cost of the same articles in the most elaborately equipped workshops of a modern manufacturing company. The work, as a whole, does not compare in strength and finish with the modern machine-shop product; but the machines give the results which are needed, last long, and, above all, suit the pockets of the buyers. The trade in this particular machine is so enormous that more than one firm manufacturing agricultural machinery has endeavoured to secure a portion of the business; but all have failed, since no one of them has been able to produce and sell the machines at double the local price and yet make a profit.

Of course, it is only the very sim-

THE HARBOUR AT VLADIVOSTOCK

plest machines which can thus be made by the Artels, this being due to many causes, including tradition, lack of tuition in finely-executed work, local conditions, etc.; and there is little probability that they will be able to extend their operations in other directions in which a higher degree of skill and knowledge is required.

It is interesting to note, however, that these Artels represent a number of powerful organizations working on a purely socialistic and communistic basis, similar to that which the Western socialistic agitators have been endeavouring to advocate as the panacea for all trade evils. We have here, in the heart of Russia and Siberia, each handicraft keeping itself practically separate, its members working peacefully, contented, untrammeled and free, this system having been in operation for scores of years in countries concerning which all sorts of misstatements have been made by people who have never lived in them for any length of time, or who have distorted what they have known to suit their own lines of argument. Although the Artels occupy this unique position, and though each member has practically equal rights of participation in their benefits, still the law of the survival of the fittest obtains, and the man who is endowed with better health, better skill and more energetic habits earns more than his dull, inapt and lazy fellow member doing the same job; the former can, and often does, become a comparatively rich man, while the latter remains as he was.

In conclusion, it may again be impressed on those who are seeking an outlet for their energy and capital that Siberia has a tremendous future and a great present worth; but that here, as elsewhere, it is only those who put experience, ability and ceaseless energy into their undertakings in the country who will succeed, and for those who are prepared to do this there need be no fear for the future.

GAS FIRING FOR LIME AND CEMENT KILNS.

By Oscar Nagel, Ph. D.

THE first extensive uses of producer gas in the arts related to metallurgical purposes, especially in connection with the manufacture of steel in the open-hearth furnace, utilizing the regenerative system of Siemens. More recently the gas producer has been extensively used in connection with the production of power, the lean gas being used in internal-combustion engines with success, and this department of industrial gas utilization seems destined to wide development. It is advantageous, however, to use producer gas for many operations involving the development of heat, and among these may be considered the calcining of lime and cement.

By using producer gas for burning lime an economy of 25 to 35 per cent. of fuel is effected, as compared with direct-fired kilns. Another advantage of gas firing is the production of a purer product, as the lime does not come in contact with the fuel, and hence remains free from ash.

The first successful producer gas-fired lime kiln was built by Steinmann. This furnace, which is shown in Figs. 1 and 2, can be used either for the burning of lime only or also for the simultaneous production of carbon dioxide. If the furnace is to be used alternately for both purposes, its upper part is provided with a pipe, *m,* for carbon dioxide and besides with a top *n,* which is closed during the reclamation of carbon dioxide.

Either anthracite, bituminous coal or lignite may be used as fuel in this case.

The shaft, *a a,* is lined with fire brick up to the top; *c c* are the gas tuyeres, these branching off from the ring-shaped gas channel *d d,* which is connected by means of channels, *e e,* with the two gas producers. The burnt lime is discharged through doors ranged at the bottom of the shaft, five circular openings, each having a diameter of about 10 inches and being fitted with small slides, being provided in each door. The air necessary for the combustion of the gases is allowed to enter through these openings and is preheated by passing through the burnt lime, the latter being simultaneously cooled thereby. The slides allow an exact regulation of the combustion and entire operation. A cleaning opening, *h h,* is provided opposite each of the four gas tuyeres, *c c.*

The valve *k,* provided in the gas main, allows the regulation of the quantity of gas admitted to the shaft. The tar contained in the gas is condensed at *l l,* and runs into the collecting chambers which are provided below and are closed air tight. Cleaning holes covered by water seal covers, which are marked in the plan view also with *l l,* are provided above the tar chambers. By means of the iron pipe, *m,* the carbon dioxide is led through washers into the saturating vessels by means of suitable pumps provided between the washers and the saturators. The limestone is charged through the iron door *n.*

All parts of the kiln have to be preheated for at least 72 hours before starting operations. After sufficient preheating, the channels have to be cleaned from flue dust and ash

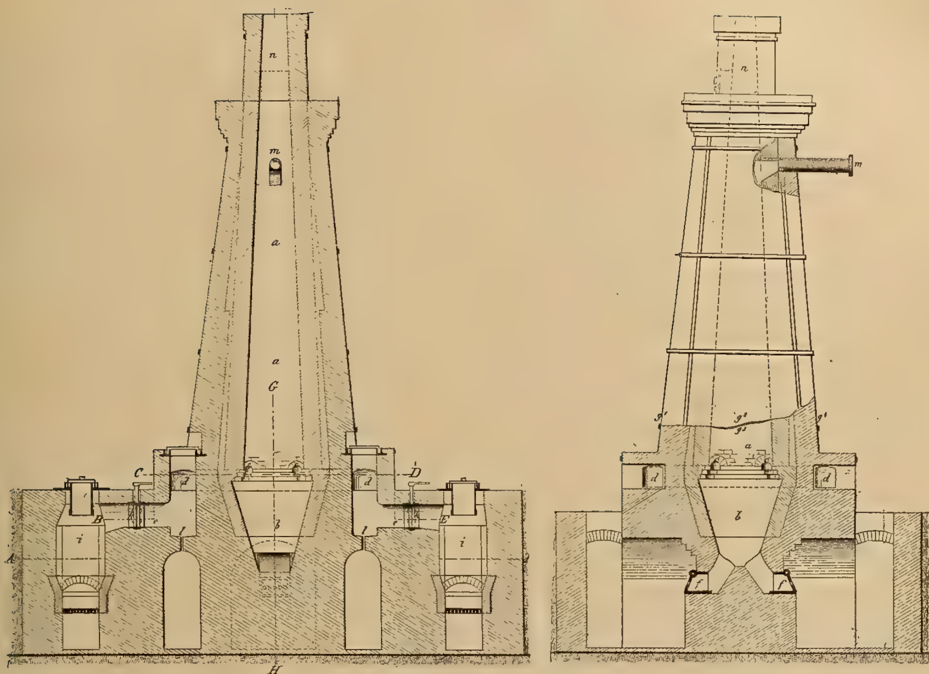


FIG. 1.—VERTICAL SECTIONS OF THE STEINMANN GAS-FIRED LIME KILN

before the charging of the limestone is started. The shaft is then loosely filled to about half of its height with pieces of limestone of about 10 inches in diameter.

After the shaft has been filled the wood-fire is started through the open discharging doors, *f f;* the heat is gradually increased until the content of the shaft appears dark red in the zone of the four lowest peep-holes. The gas producer is then charged and started, and the gas-valve slightly opened and the gas is lighted. The first batch of lime is discharged two hours after the gas has been lighted, and, thereafter, in intervals of not less than one-and-a-half and not more than three hours. After every discharge at the bottom, fresh limestone is charged through the top.

About every two months the channels, valves, tuyeres, etc., have to be cleaned, which is readily done by letting the coal burn down in the gas producers to a point near the incandescent layer, whereby an ignition of the tar is effected. Simultaneously, the covers of the cleaning openings, *h h,* leading to the tuyeres, and the covers above the tar chambers, *l l,* are removed, and then the tuyeres and ring channels cleaned.

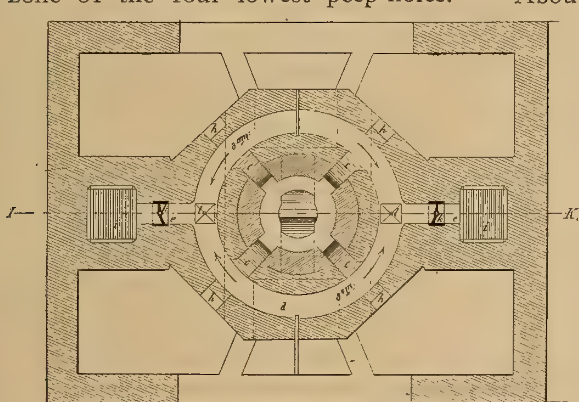


FIG. 2.—SECTION PLAN OF THE STEINMANN KILN

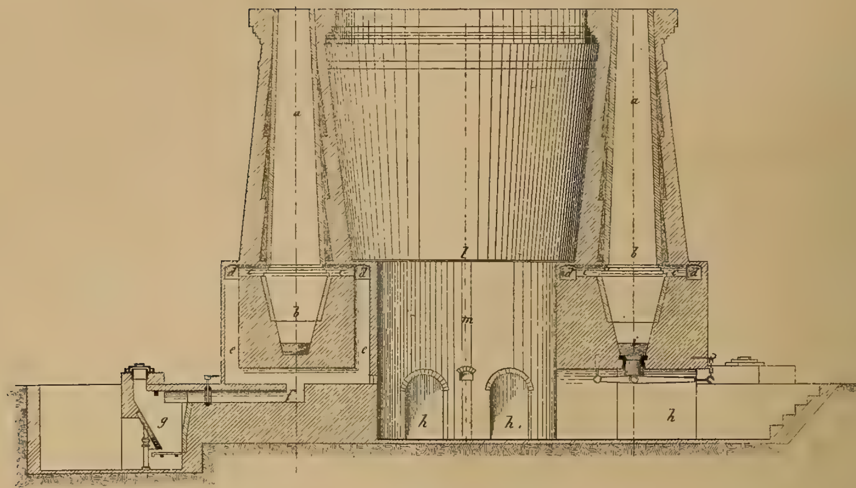


FIG. 3.—VERTICAL SECTION OF THE BASTION KILN

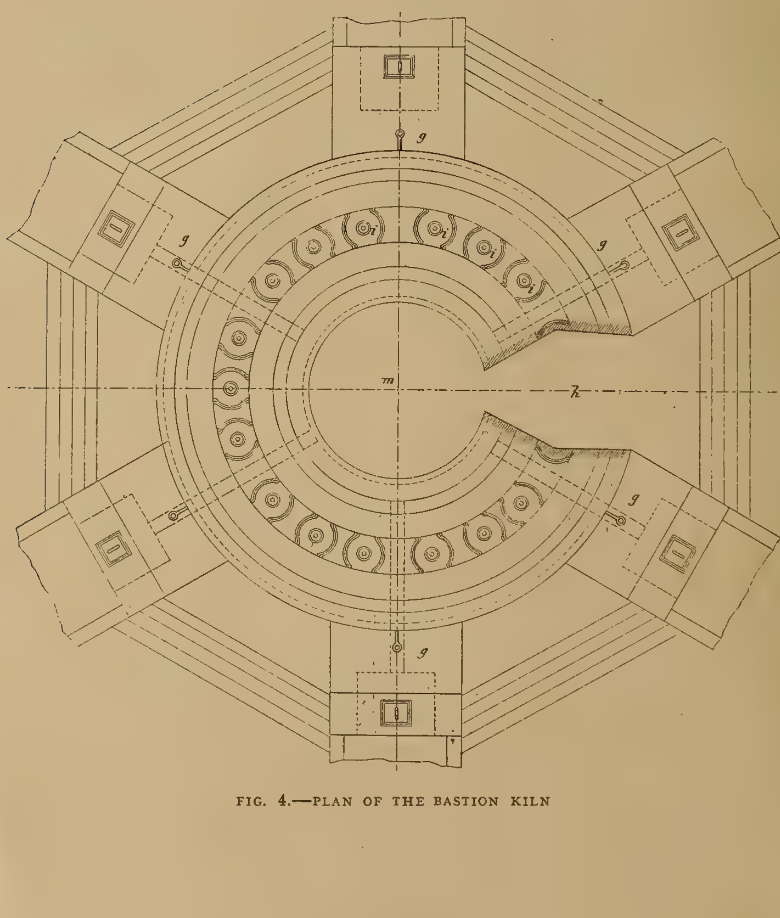


FIG. 4.—PLAN OF THE BASTION KILN

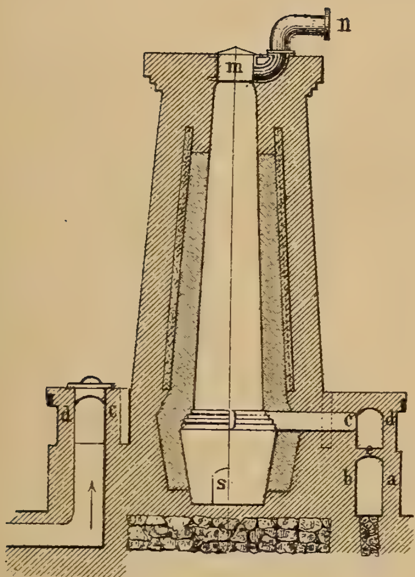


FIG. 5.—THE HODECK KILN. VERTICAL SECTION

Then everything is restored to the original condition, the gas producer rapidly recharged and the regular operation resumed. The ring channel is provided at two opposite sides with two horizontal movable slides, which are closed, if the furnace should have to be repaired on one side without shutting down the other side. According to the size of the kiln the operation can be stopped for four or six days without necessitating a regular preheating when operations are resumed. However, before shutting down, the gas producers have to be filled up to the top, the valves *k k* closed, as also the air inlets at *f f*, and the discharging doors themselves, and the top of the shaft covered.

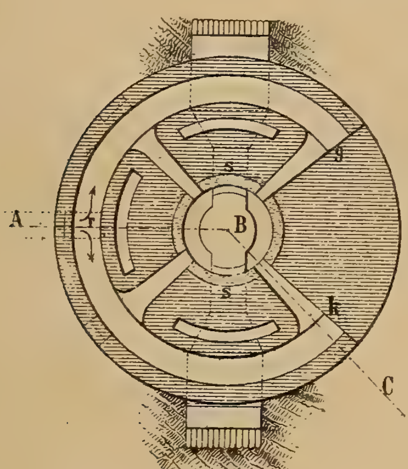


FIG. 6.—HORIZONTAL SECTION OF HODECK KILN

As the flame in this kiln goes mainly vertically upward, there is a limit for the maximum admissible diameter, which was found by Steinmann at about five feet. A furnace with the larger diameter would contain unburned lime in the center. The length of the flame in the vertical direction, however, can be made from 25 to 28 feet. The furnace of five feet diameter and 28 feet of height produces ten tons of lime in 24 hours. For larger capacities these kilns have to be built with elliptical cross-section. The first cost of such a furnace is not greater than the cost of a direct-fired kiln.

The Steinmann "Bastion" kiln, which is shown in Figs. 3 and 4, is intended for large capacities. A number of them are in successful operation, with a capacity of 35 tons per day, and have given much better results in fuel economy than direct-fired kilns. The construction of this type will be easily understood from the illustrations.

At *a a* is the shaft in which the limestone is burned; the burned material is collected in *b b; g* are the gas producers, of which there are six at the diameter of the furnace ring of 33 feet, *f* is the gas main, *e* the branch channels, *d* the ring channels, from which the tuyeres *c* branch off to the shaft; *i* are the discharge openings for the burned lime, which are closed by a highly-burned, cone-shaped fire-clay valve. The latter is more or less opened by means of a lever, whereby the admission of combustion air is regulated. The valve seats *i* are lined with iron castings. The combustion air absorbs the heat from the burned material contained

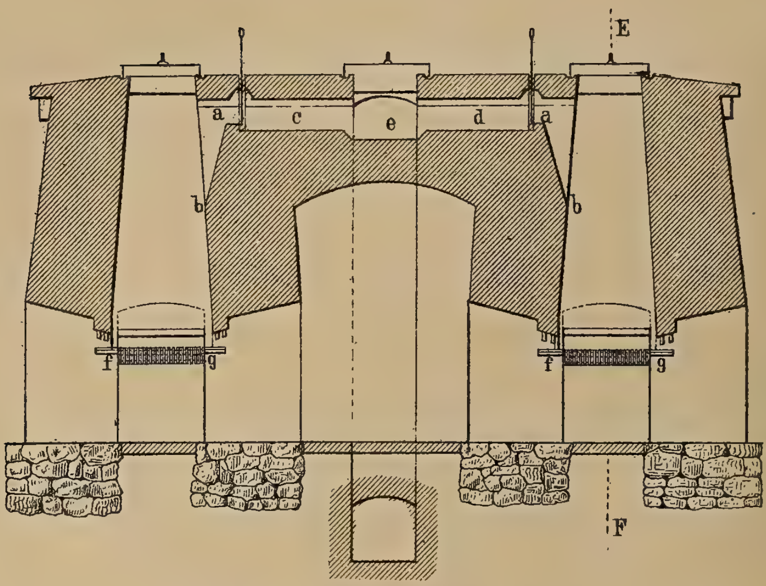


FIG. 7.—VERTICAL SECTION OF HODECK PRODUCERS

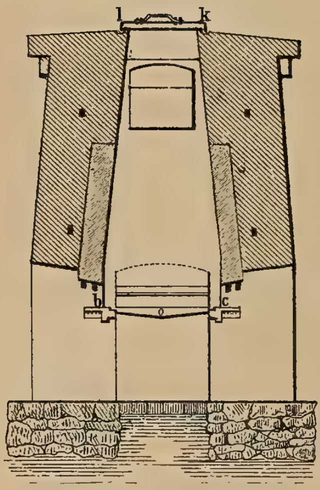


FIG. 8.—TRANSVERSE SECTION OF HODECK PRODUCER

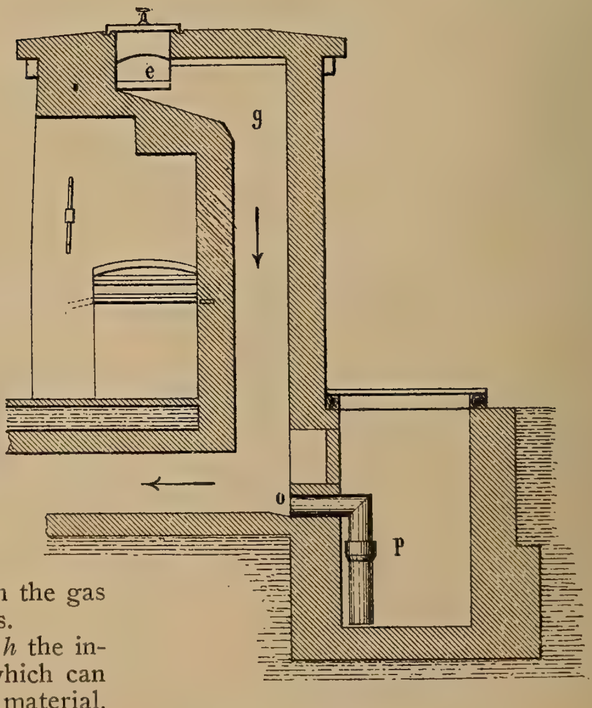


FIG. 9.—PATH OF GASES IN HODECK SYSTEM

in *d*, and forms a flame with the gas entering through the tuyeres.

Through the openings *h h h* the interior space *m* is reached, which can be used for storing the raw material, which, by proper elevating arrange-

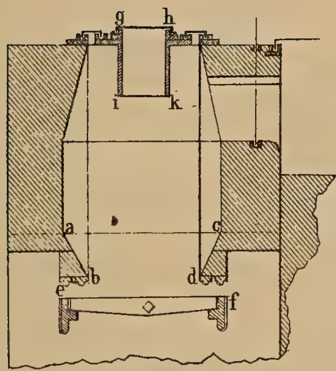


FIG. 10.—HODECK PRODUCER

ments, can be lifted conveniently to the top of the shaft; *l* is a working platform. The hoppers *i* are separated from each other by saddle-shaped ribs, whereby the burned material is discharged uniformly to the left and right sides. These furnaces are started in practically the same manner as the kilns first described.

A gas-fired lime kiln, designed by Frueling, is about of the same construction as the one shown in Fig. 1, the only difference being that the

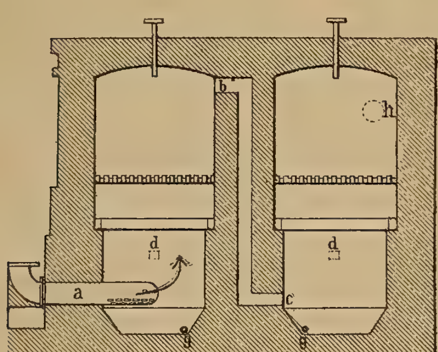


FIG. 11.—HODECK GAS WASHER

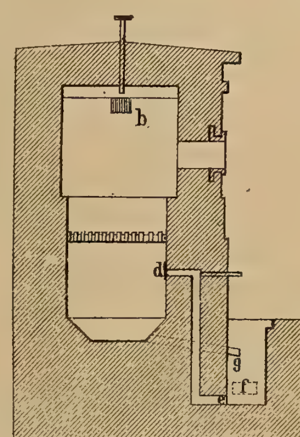


FIG. 12.—SECTION OF HODECK WASHER

cross-section is rectangular instead of circular.

Hodeck has improved some of the features of the Steinman kiln.

In the Hodeck kiln (Figs. 5-12) the gas channel is free at all sides, so as to facilitate cooling. It rests upon a channel, closed by arch *e*; this arch forms the sole, which is connected at *r* with the gas channel. The ring channel does not go all around but stops at *g* and *k*. Beginning from the inlet opening *r* the sole of the channel rises towards *g* and *k* by about 9 inches, while the cover remains horizontal. This decrease of the cross-section is justified by the quantity of gas which decreases towards *g* and *k*. The lime is removed at *s*, the gas through *m n*.

The Ponsard lime kiln is characterized by its moderate height and by the use of highly preheated air for the combustion; the heating of the air being combined with the cooling of the carbon dioxide gas produced. As shown in Fig. 13, the apparatus consists of a gas producer *a*, the lime kiln proper, the front part *b*, of which is used for the combustion of the producer gas, and the larger part *c* for the reception of the limestone. The apparatus *d*, for heating the air, is built of cast-iron tubes. This apparatus also effects the cooling of the carbon dioxide, which passes through pipe *e*. The mixture of gas and air takes place in a simply-constructed apparatus, in which the hot combustion air and the gas meet at right angles. The burned lime is discharged through *f*,

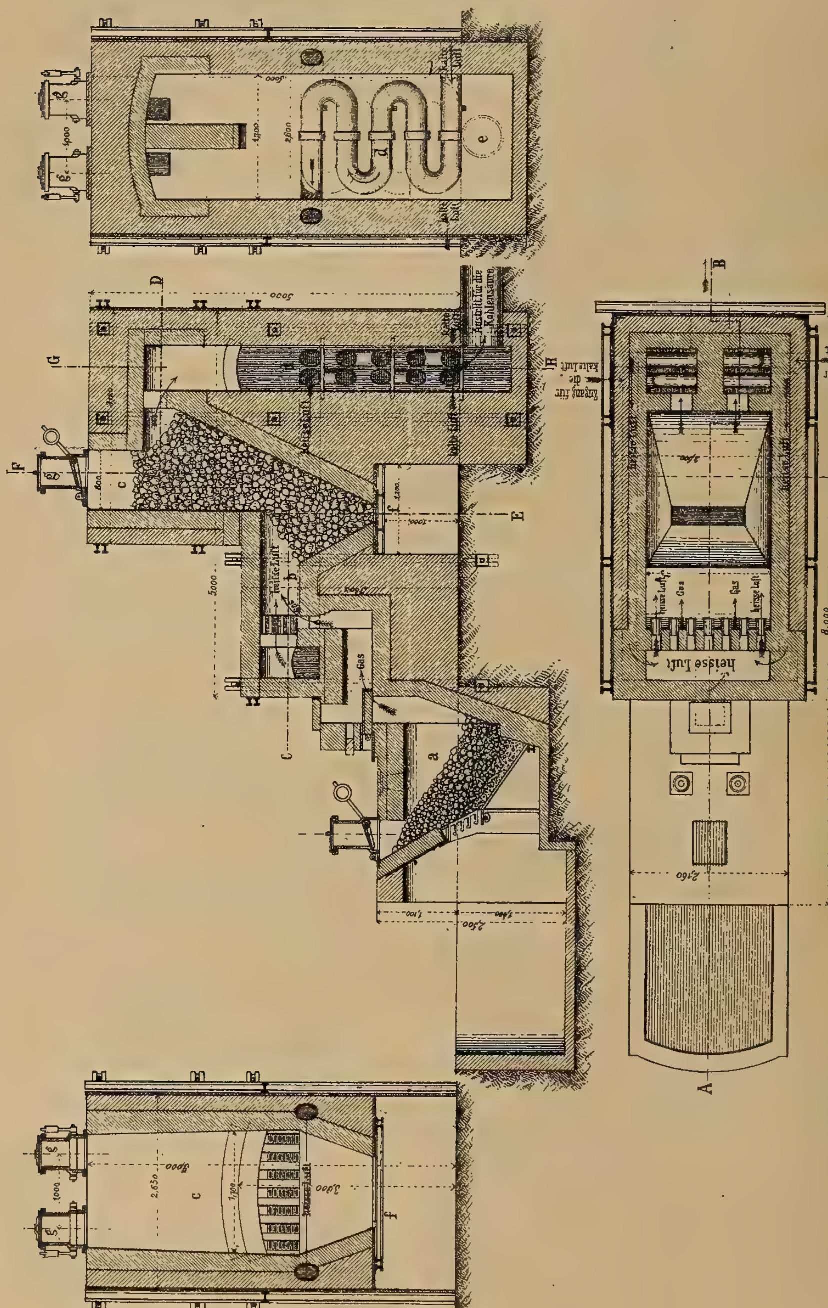


FIG. 13.—THE PONSARD SYSTEM, SHOWING PRODUCER, KILN, AND APPARATUS FOR PREHEATING THE AIR

and the limestone through the charging hopper *g*, which is provided with a cover resting in a water seal. The illustrations plainly show that only slight quantities of air can enter the shaft when a charge is made.

Isserlis has designed a kiln of rectangular plan, which is shown in Fig. 14. The preheating shaft is separated by the separating walls *g* into compartments 1, 2, 3 and 4. Each one of these compartments is supposed to have a capacity of about 10 tons per day. The furnace shown in the illustration has four compartments, but this furnace can, of course, also be built with a larger or smaller number of compartments. The producers and the discharging openings are arranged alternately at the longitudinal sides of the kiln.

A kiln which has been designed by Schmatolla is shown in Fig. 15. This kiln is said to have a high capacity and to be of low first cost, the excellent result being effected by the fact that a narrow shaft similar to a stack, open at both ends, is built into a very wide cylindrical or conical shaft. Hence, a ring-shaped shaft is obtained, which can be given any suitable width. In this kiln the producer gas is allowed to enter both from the inside and the outside wall,

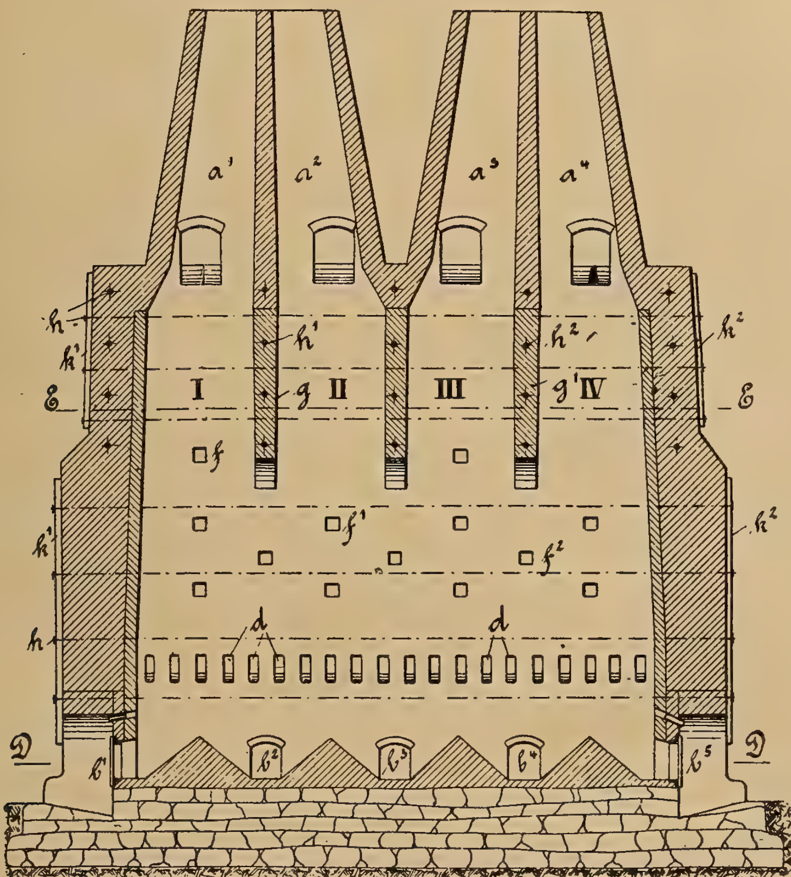


FIG. 14.—THE ISSERLIS RECTANGULAR KILN

and the material can also be discharged through openings arranged in the inner or outer wall. An elevator can be run in the inner shaft for lifting the limestone to be charged into the kiln. The figure

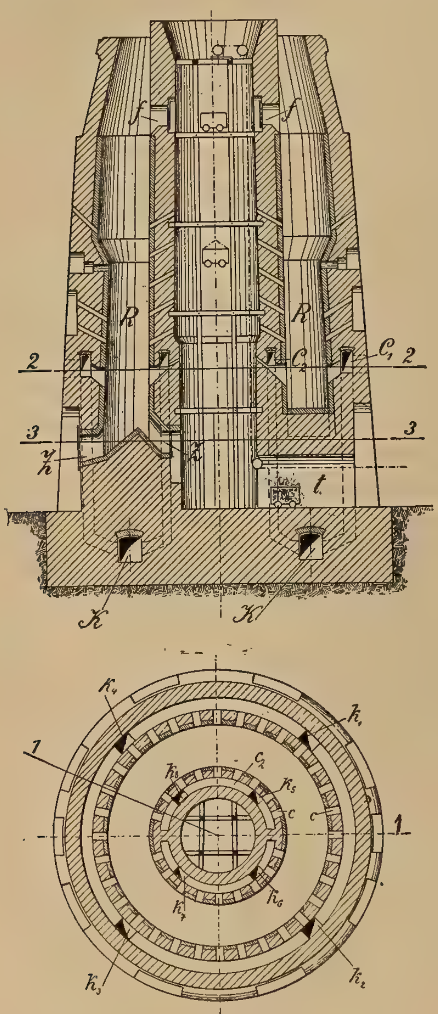


FIG. 15.—PLAN AND VERTICAL SECTION OF SCHMATOLLA KILN

shows a vertical section through the center of the shaft, and also a horizontal section in line 2-2 through the zone of the gas admissions.

The producer gas enters the ring channel K provided below the ring-shaped shaft and passes from here

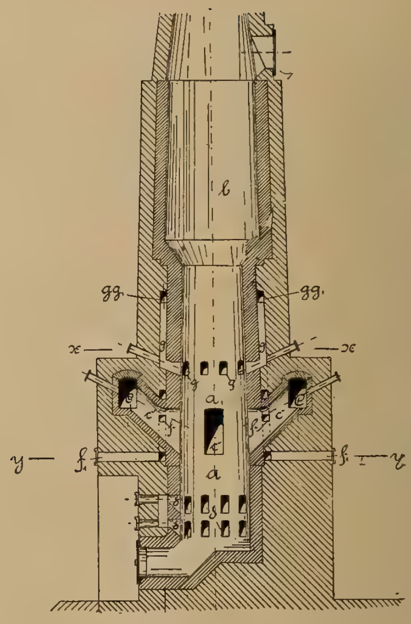


FIG. 16.—ANOTHER TYPE OF SCHMATOLLA KILN

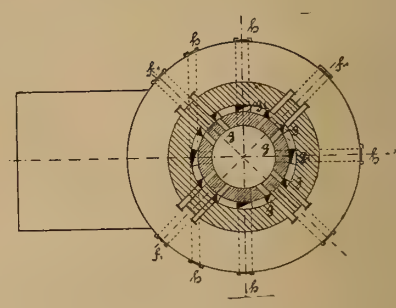


FIG. 17.—HORIZONTAL SECTION ON X-X

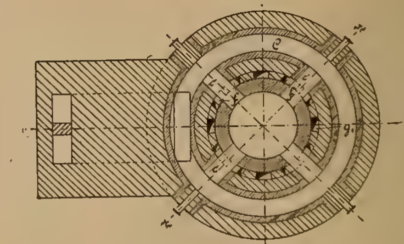


FIG. 18.—HORIZONTAL SECTION ON Y-Y

through vertical channels $k_1\,k_2\,k_2\,k_4$ to the outside ring-shaped gas channel C_1, and through four vertical channels $k_5\ k_6\ k_7\ k_8$ and to the inner ring-shaped gas channel C_2.

A number of radially-arranged connected channels c lead to the ring shaft R, both from C_1 and from C_2. The combustion air enters through the outside discharging doors Z and the inner discharging doors z. The limestone is charged through openings f. The central shaft is connected to the outside through tunnel-shaped channels t.

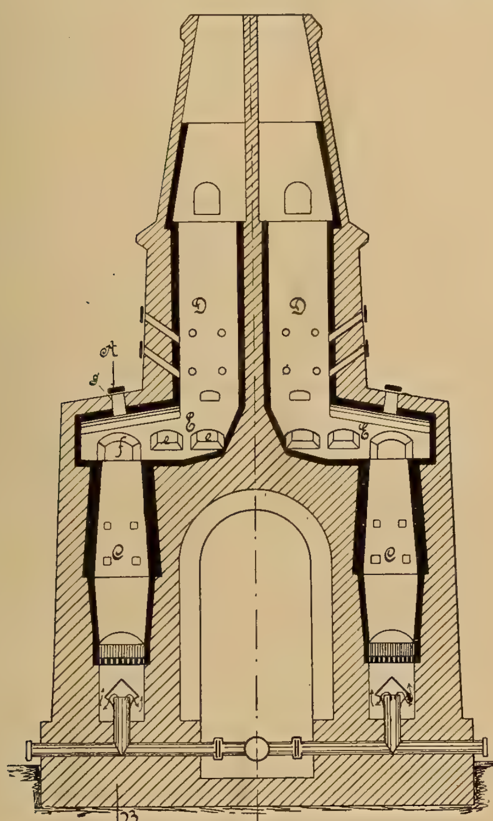


FIG. 19.—VERTICAL SECTION OF DIETZ CEMENT KILN

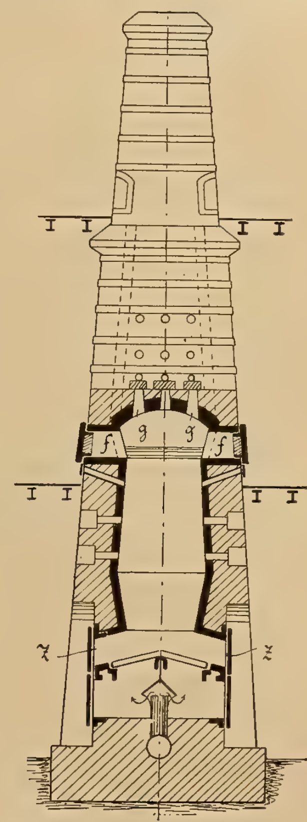


FIG. 20.—TRANSVERSE SECTION OF DIETZ CEMENT KILN

An excellent lime kiln designed by Schmatolla is shown in Figs. 16 to 18. Fig. 16 is a vertical section, 17 a horizontal section on line x-x, and 18 a horizontal section on line y-y. The gas enters the shaft from the main C through radially-arranged channels c, provided about six feet above the discharge openings. The secondary air enters through tuyeres c, directly above the discharge openings. The gas channels c are surrounded by a circular air channel, fiom which the air can enter into the gas channel through channels f, which are supplied from channels f_1. The secondary air entering through g passes through horizontal channels h, which are provided in the cooling shaft and can be regulated by slides. At first the air rises through vertical channels g_1 arranged behind the fire-brick lining, and then goes downward through channels g_1. Both g and g_1 are of a T-shape. The sec-

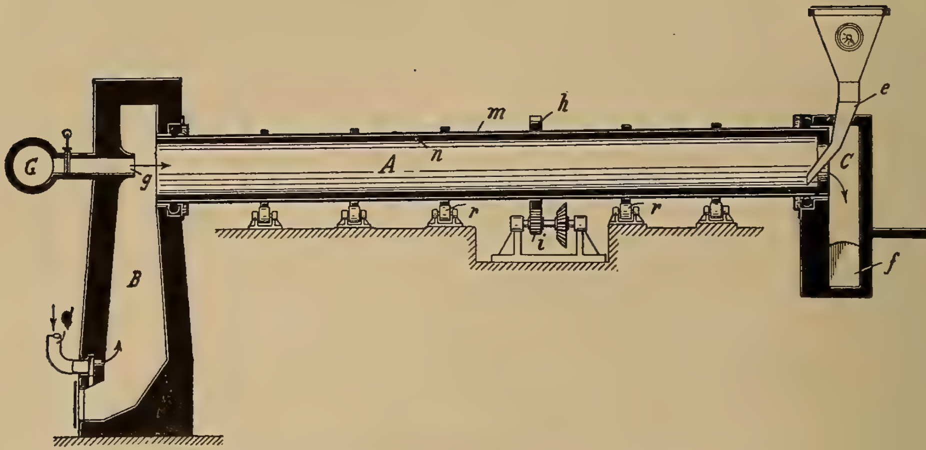


FIG. 21.—GAS-FIRING ARRANGEMENT OF ROTARY CEMENT KILN

ondary air passing through these channels, which are provided behind the incandescent brickwork of the shaft, is highly preheated.

A description of the Dietz cement kiln, which can be easily transformed to gas-firing, will probably be of interest at this place. This kiln is shown in Fig. 19, a section on line *AB* in Fig. 20. The upper shafts are carried by the arch between the lower shafts. In the upper parts of the lower shafts *C* is the hottest zone, in their lower parts the cooling zone; the upper shafts *D* are the preheating shafts. They communicate through the hearth *E,* provided with working doors *e* and *f*. Fuel can be charged through openings *g* and distributed through doors *f*. Through doors *e* and *f* the material is raked from the preheating shaft into the burning shaft proper.

From time to time the material is discharged through doors *z z;* fuel is charged through *g*, and then the preheated material drawn from the preheating into the burning shaft, while

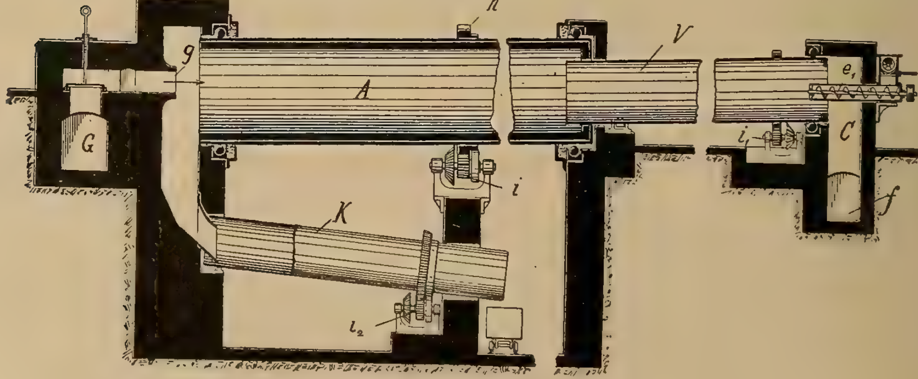


FIG. 22.—ROTARY CEMENT KILN, WITH ARRANGEMENT FOR PREHEATING THE AIR

fresh material is charged from the top. For gas-firing arrangements have to be made for preheating the air.

If gas-firing is used in rotary cement-kilns, the pulverizing of coal is done away with, a saving of about 25 per cent. effected, and a product free of ash obtained. Fig. 21 shows a longitudinal section of such a kiln. The material is charged through *C*, the gas enters through pipes *g* branching off the main *G*, while the air is entering through *d*, being highly preheated by passing through the burned clinker contained in *B*, the clinker being cooled simultaneously. There is no difficulty in producing the temperature required for cement burning.

In the kiln shown in Fig. 22 the burned clinker is discharged through *K*, in which also the combustion air is preheated. The construction will be easily understood from the illustration.

TURBO-ELECTRIC PROPULSION FOR VESSELS

By R. M. Neilson

A CONSIDERABLE amount of discussion has recently taken place as to the merits of employing, for the propulsion of steamships, an arrangement of machinery comprising one or more steam turbines, each direct coupled to an electric generator, and one or more electric motors direct coupled to a propeller shaft, or shafts, the motors receiving electric energy supplied by the generators.

This turbo-electric scheme has already been tried, but only to a very limited extent. It has, for example, been applied to fireboats at Chicago, in which case it offered special advantages.

In these Chicago fireboats a steam turbine is direct coupled to an electric generator and also to a centrifugal pump. The generator supplies current to motors which drive the screws for propelling the vessel; the pump is used for fire-extinguishing purposes. The turbine is a two-stage Curtis machine of 660 horse-power, running at 1,700 revolutions per minute; the generator is a continuous-current, 275-volt machine, with a maximum capacity of 200 kilowatts; the pump is capable of delivering 3,750 gallons per minute against a head of about 150 pounds per square inch. This triple unit has one common bed-plate, three bearings and two shafts connected by a flexible coupling; the generator is situated between the turbine and the pump, with its commutator on the pump side.

The turbo-electric drive also appears to be specially advantageous in the case of certain kinds of dredges, salvage vessels, repair ships, etc., in which the power required for propulsion does not bear such a high ratio to the power required for other purposes as is common in cargo, passenger and war vessels.

With such special types of ship—or some of them—the author is certain that the turbo-electric scheme possesses such distinct advantage as to render its adoption advisable. Many advocates of the scheme are, however, much more ambitious; and the main object of this article is to enable a decision to be come to as to whether the scope of the scheme ends with a few special types of ship or whether it can be usefully employed in any of the usual types of steamship, such as cargo boats, long or short-journey passenger steamers, battleships, cruisers, or torpedo craft.

Although the merits and demerits of the system have been already frequently discussed in a general way, the writer considers that a more detailed investigation as to the weight, coal consumption and cost of machinery in a vessel fitted with a turbo-electric drive and a comparison of these with the corresponding items in the case of a vessel propelled by ordinary reciprocating engines may be helpful in promoting sound views on the subject.

Most attention will be given in this article to cargo boats, for the reason subsequently given, and a vessel of this class will first be considered. Suppose this ship to be of the "three-island" (poop, bridge and forecastle) type, 385 feet long, 50 feet beam and 29 feet 6 inches moulded depth, and built to a good specification for

a tramp, say to Class A1 at Lloyds. The load draft would be about 24 feet 3 inches, displacement 10,000 tons, and coefficient 0.75; and reciprocating engines of 2,000 indicated horse-power might be expected to give it a speed of 10 to 10½ knots.

Allowing 14 per cent. of the indicated horse-power to be wasted in friction in the engine and propeller shaft bearings, the brake-horse-power available at the propeller is 1,720. With a steam pressure at the boilers of 180 pounds per square inch above atmosphere (and no superheater), the writer puts the steam consumption at full power at 14.5 pounds per indicated horse-power-hour. This is on the assumption that the sea temperature—which affects the vacuum—is at 70 degrees F. This sea temperature is taken as a kind of mean for the world's trade. For vessels intended to steam only in the North Sea or Northern Atlantic, a lower sea temperature could be assumed which would favour the turbo-electric scheme, which depends for economy on a high vacuum. It is true that lower steam consumptions than this have been obtained in practice; but the writer considers that it would not be justifiable to take a lower steam consumption under the conditions assumed, which include only a moderate weight of propelling machinery and opportunity for only occasional overhaul. The figure given—14.5 pounds per 2 horse-power-hour considered as an average—is believed to be practically attainable. Considerably higher steam consumptions are common, if not the rule. The steam consumption per brake-horse-power delivered to the propeller will then be 16.8 pounds per hour.

If a vessel of the same dimensions and displacement were arranged for the turbo-electric drive with a single high-speed turbine, such as is employed on land for electric driving, but of a lighter construction, and if the steam were generated, as before, at 180 pounds and supplied to the turbine at 150, the latter, with a 27.8-inch vacuum (with barometer at 30 inches), would require about 19 pounds of steam per kilowatt-hour at generator terminals. The electrical and mechanical losses in the motor, the loss in the switch gear and the friction in the propeller shaft the writer puts as equivalent to 11 per cent. of the electrical output of the generator. If the air pump and circulating pump are driven electrically, they would require, he considers, together 12 to 20 electrical horse-power; that is, 3/5 per cent to 1 per cent. of the power of the main turbines.* Taking 1 per cent. to include the steam consumption of the feed pumps, etc., the total steam consumption per brake-horse-power delivered to the propeller works out at $19 \times \dfrac{746}{1{,}000} \times \dfrac{100}{88}$ = 16.1 pounds per hour, which, compared with the 16.8 pounds of the reciprocating-engined boat, gives the turbo-electric scheme the advantage of a little over 4 per cent. in steam economy. For the same brake-horse-power delivered to the propellers in the two cases, namely, 1,720, the electric horse-power at the generator terminals in the turbo-electrically-driven ship would be

$$1{,}720 \times \frac{100}{88} = 1{,}955.$$

The weights of machinery in the two cases will now be discussed and compared.

The weights of propelling machinery of cargo boats, except in a few odd cases, do not vary very much. The weights assumed by the writer are based on the practice of one of the largest manufacturers of cargo-boat engines and are given in Table I., and alongside of them are placed the estimated weights of machinery in the turbo-electrically-engined ship. The slightly less steam consumption

* It has been assumed that the circulating water discharge port is not more than 5 feet above the water (sea) level.

in the latter has been taken into account in fixing on its boiler power. A single set of engines and single propeller making 70 revolutions per minute have been assumed in the case of the reciprocating-engined ship, and twin propeller shafts, each with a single propeller rotating at 80 to 100 revolutions per minute, in the case of the turbo-electrically-driven vessel.

The weights of the turbo-alternators (excluding very small machines) as made by one of the leading builders, the turbines being of the Parsons type, are usually between the limits of 40 and 50 pounds per electrical horse-power of rated capacity; but as the turbines can always, and the generators often, run for an indefinite period at an overload, the weights per maximum continuous electrical horse-power in the present case will be less. Moreover, a considerable reduction in weight can probably be effected by alterations in design which are not called for in land machines, in which weight is of much less consequence. In putting the weight, therefore, at 35 pounds per maximum continuous electrical horse-power at the generator terminals, the writer is probably not giving a lower figure than could be readily attained.

The weight of the main electric motors, switch gear, conductors, etc., will depend to a considerable extent on the electrical scheme adopted; but will probably be somewhere between 40 and 55 pounds per brake-horse-power at the motors, i. e., between 35 and 47½ pounds per electric horse-power at the generator terminals. The figure assumed for incorporation in Table I. is 40 pounds per electrical horse-power at generator terminals.

TABLE I.—WEIGHTS OF MACHINERY WITH DIRECT RECIPRO-DRIVE AND WITH TURBO-ELECTRIC DRIVE.

	Recipro-Drive Single Propeller. 70 Revolutions per Minute.		Turbo-Electric-Drive, Twin-Screws. 80–100 Revolutions per Minute.	
	Weight per I. H. P. Pounds.	Total Weight. Tons.	Weight per E. H. P. at Generator Terminals. Pounds	Total Weight. Tons.
Boilers with water, mountings, feed pumps, feed tanks	300	268	288	251.2
Main engines (including in the case of the recipro engines the platforms above the engine-room floor)	212	189.4	35	30.5
Main condenser with water pipes, and water in condenser and pipes			40	34.9
Air pump (with motor in turbo-electrc-drive)			5	4.4
Circulating pump (with motor in turbo-electric-drive)			2	1.7
Main electric motors, switch gear, and conductors	0	.....	40	34.9
Propellers and propeller shafts	45	40.2	45	39.3
Spare gear	24	21.4	15	13.1
Total weight	581	519.	470	410.

The same weight has been assumed for the twin propellers and shafts of the turbo-electrically-engined ship as for the single propeller and shaft of the other, the twin shafts being not only of less diameter, but possibly of shorter length.

As regards spare gear, it is thought that the turbo-electric boat will require to carry considerably less than the other; but about 15 tons has been allowed for in the former.

It will be seen that the turbo-electric scheme appears to allow of a considerable reduction in weight of machinery. There is also a slight saving in amount of bunker coal required to be carried; but this will not be worth taking into account except for long voyages at full power, especially as a very slight variation in the efficiencies assumed would bring the two schemes into equality in this respect.

The saving in weight of machinery, however, by adopting the turbo-electric scheme amounts to 109 tons, which would allow of the cargo being increased by this amount if accommodation could be found for it.

This will depend on the position and cubic space allotted to the turbo-electric machinery, and it should be possible to dispose this in less space than is required for the machinery in the recipro-driven ship. It may be mentioned that the turbine and electric generator can be installed either above or alongside the condenser plant. It will be preferable, but not absolutely necessary, to place the turbine close to the boilers. The minimum weight of propeller shafts will be obtained by placing the motors as close to the propellers as the lines of the ship and the large diameter of the motors will allow of; but the motors can, if desired, be placed at a considerable distance from the stern of the vessel and adjacent to the rest of the machinery, so as to be more directly under the observation of the engineer on watch.

The turbo-electrically-engined ship would cost much more for the same displacement of vessel and same engine power, and would require to carry an engineer, or engineers, skilled in electrical machinery. The former point is a distinct disadvantage, whatever may be said about the latter. The turbo-electric scheme possesses, however, several points of superiority, besides enabling more cargo to be carried. The advantage of twin propeller shafts over a single shaft as regards the risk of total disablement is well known. The smaller size of the propellers on a twin-screw boat also tends to reduce the loss of efficiency in rough weather through the propeller blades leaving the water. The weight of the revolving parts of the motors on the propeller shafts in the turbo-electrically-engined boat will reduce the risk of accident through racing in rough weather.

The advantages and disadvantages of the turbo-electric drive are summarized in Table II.

TABLE II.—ADVANTAGES AND DISADVANTAGES OF THE TURBO-ELECTRIC DRIVE.

Advantages.	Disadvantages.
1—More cargo carried.	1—More skilled attention.
2—Less coal consumption.	2—Greater initial cost.
3—Greater propeller efficiency in rough weather.	
4—Less risk of accident due to propeller racing.	
5—Vessel not totally disabled if propeller shaft breaks or rudder put out of action.	

In Table III. the points of relative merit are compared of this scheme and three direct-drive alternatives. The numerals in this table represent first place, second place, etc., in order of merit. All the points considered are not, however, it should be noted, of equal importance, so that nothing is to be derived from summing up the marks. The relative advantages of the four schemes under the third heading has been left open.

Instead, however, of comparing vessels of equal displacement, it is more instructive from a commercial point of view to compare ships of equal cargo-carrying capacity. In the two boats already compared the weight of machinery in the recipro-driven ship was estimated to be 109 tons more than that in the other.

TABLE III.—COMPARISON OF THE TURBO-ELECTRIC-DRIVE WITH THREE DIRECT DRIVE SCHEMES

Points of Relative Merit.	Direct Drive. Single Set Reciprocating Engines.	Direct Drive. One H. P. and Two L. P. Turbines.	Direct Drive. Two Sets of Reciprocating Engines and One L. P. Turbine.	Turbo-Electric-Drive.
Initial cost of machinery	1	2	3	4
Expense in upkeep of machinery	..	..	..	..
Weight of machinery. Weight of cargo that can be carried	2	3*	3	1
Coal consumption	3	4	1	2
Risk of accident sufficient to seriously cripple the vessel, considering also the extent of the crippling	4	1	2	3
Weight of bunker coal	3	4	1	2
Ability to arrange machinery in ship to suit cargo and reduce cost of loading and unloading	3	2	3	1
Maintenance of propeller efficiency in rough weather	4	1	1	3
Reversing power	2	3	3	1

* The turbines would require to be large to give the low speed of rotation requisite for fair propeller efficiency.

The former vessel could, however, be increased in size, so as to carry this extra weight of machinery and still be able to take the same weight of cargo. If the beam only were increased, 9 inches additional would seem to be sufficient. The chief particulars of the two vessels would then be as follows:

TABLE IV.—COMPARISON OF RECIPRO-DRIVEN AND TURBO-ELECTRICALLY-DRIVEN CARGO BOATS OF EQUAL CARGO-CARRYING CAPACITY.

	Recipro-Drive.	Turbo-Electric-Drive.
Length	385′ 0″	385′ 0″
Beam	50′ 9″	50′ 0″
Moulded depth	29′ 6″	29′ 6″
Load draft	24′ 3″	24′ 3″
Displacement	10,150 tons.	10,000 tons.
Co-efficient	0.753	0.75
Weight of hull	2,545	2,515
I. H. P. or E. H. P.	2,030*	1,955
B H. P. at propellers	1,746*	1,720
Weight of machinery	527*	410
Light weight	3,070	2,925
Dead weight	7,080	7,075
Cost of hull	£34,150	£33,750
Cost of machinery	£11,000	£19,200

* 1½ per cent of horse-power has been allowed for the increased beam and displacement.

Tables V. and VI. show how the total cost of machinery in the two cases, as given in Table IV., has been arrived at. In the case of the turbo-electric scheme the cost has been based on the assumption that three-phase transmission would be adopted with the voltage at 4,500, periodicity about 25, and revolutions per minute of generator 1,500. The questions of best speed of generators, voltage periodicity, speed changing devices, etc., offer opportunity for much discussion; but this discussion may well be postponed till it is decided if the turbo-electric drive can with advantage for economical reasons (or in the case of war vessels for economic, strategical and tactical reasons) be adopted in any except a few special vessels, which might call for special designs and arrangements of machinery, as in the case of the Chicago fireboats previously referred to.

TABLE V.—RECIPRO-DRIVEN SHIP. 2,030 I. H. P SINGLE SCREW, 70 R. P. M. ESTIMATED COST OF MACHINERY.

1	Boilers; Boiler mountings; Feed tanks; Feed pumps; Boiler room spare gear	£3,300
2	Main engines complete with all accessories; Thrust block; Engine-room spare gear	5,100
3	Propeller; Propeller shaft; Spare gear	1,500
4	Winches; Winch condenser; Ash hoist; Deck piping; Spare gear	1,100
	Total machinery	£11,000

The recipro-driven boat, therefore, costs £400 more than the other for hull, but £9,200 less for machinery, the net advantage being thus in its favour to the extent of £8,800.

The turbo-electrically-propelled boat may, however, have an advantage as regards coal consumption, and it will be instructive to consider what this may amount to in a year.

TABLE VI.—TURBO-ELECTRIC SHIP. 1955 E. H. P. TWIN-SCREWS 80-100 R. P. M ESTIMATED COST OF MACHINERY.

1	Boilers; Boiler mountings; Feed pumps; Feed tanks; Boiler room spare gear	£3,180
2	Turbines; Generators; Special marine accessories; Spare gear	8,500
3	Main condenser; Circulating pump and motor; Circulating water pipes; Air pump and motor; Spare gear	1,100
4	Main electric motors; Starters; Speed control devices; Spare gear	4,500
5	Propellers; Propeller shafts; Spare gear	1,750
6	Electric cables	70
7	Winches; Winch condenser; Ash hoist; Deck piping; Spare gear	1,100
	Total machinery	£20,000

The slightly greater power required for the recipro-driven boat, owing to its 1½ per cent. excess beam and displacement, can be held to be balanced by its higher temperature of feed water due to the lower vacuum, so that the only advantage as regards coal consumption of the turbine boat will be due to its being able to obtain a slightly higher brake-horse-power at the propellers per pound of steam consumed. The ratio of the steam consumption has been taken in a previous part of this paper to be 88/86; with this ratio

the turbo-electric boat would, at full power, consume about half a ton of coal per day less than its rival. If the boats each ran 250 days in the year, the annual difference in coal consumption would amount to 125 tons. There is a difficulty in fixing the exact consumptions in the two cases, but a fair amount of certainty that the difference would be something between zero and 300 tons per annum. The saving in the annual coal bill by adopting the turbo-electric scheme would not, therefore, be sufficient to warrant the extra initial cost of the system, which is roughly, as aforesaid, £9,000. In fact, a greater reduction in coal consumption could be obtained by retaining the reciprocating engines and installing superheaters.

With no prospect of direct pecuniary advantage by adopting the turbo-electric drive for cargo boats, it is for shipowners and marine engineers to say if the scheme has sufficient other advantages to warrant its adoption for such vessels. The writer is inclined to answer the question in the negative.

There remain to be considered other classes of steamships, e. g., passenger steamers and warships.

In the classification of steamships a torpedo-boat destroyer may be considered as one extreme and a cargo boat as the other, battleships, cruisers and passenger steamers occupying intermediate positions, so that, having considered a cargo boat, it will be interesting to go to the other extreme and consider a destroyer.

The direct-driving turbines of destroyers weigh, the writer understands, somewhere about 10 pounds per horse-power. The turbines, generators and motors for a turbo-electrically-propelled destroyer would necessarily, he considers, involve a very much greater weight, although the motors would weigh much less than in the cargo boat just considered, owing to the higher permissible speed of rotation.

Considering the relatively low propeller efficiency in direct-drive turbine destroyers the difference in steam consumption between the direct and the electric drive might be expected to be considerably greater in the case of a destroyer than in the case of a cargo boat, and this would not only reduce the amount of coal (or oil fuel) to be carried, but would also reduce the boiler-room weights. The reduction in both these items of even 15 per cent. could not, however, the writer considers, compensate for the weight of the electrical machinery, so that it is difficult to see how the adoption of electric transmission could produce improvement either in the speed or the radius of action. The electric drive offers, no doubt, some other advantages; but these do not appear to the writer to be nearly sufficient to justify its adoption. It would, for example, allow a parent ship to supply electric power for propulsive purposes to a fleet of destroyers when these were cruising, so that the coal bunkers of the latter could be maintained full for subsequent use in independent work.

As, as aforesaid, battleships, cruisers and passenger steamships occupy positions intermediate between the cargo boat and the destroyer, it seems unnecessary to lengthen this paper by giving them separate consideration.

In conclusion, the writer begs to record his thanks to friends who have kindly aided him in his investigations.

CONCRETE PILES

By J. F. Springer

I.—FOUNDATIONS UPON CORRUGATED AND MOLDED PILES

THE tremendous advance in the price of wood witnessed in recent years intensifies the interest otherwise felt by engineers in the concrete pile. Nor is there prospect that the cost of the large and sound sticks used for piling will decrease. In fact, the probabilities are in the contrary direction. But concrete as a fully adequate substitute is confidently recommended and accepted by hard-headed, practical men. Indeed, the advocates of this comparatively new system do not hesitate to claim not merely equality but a decided superiority.

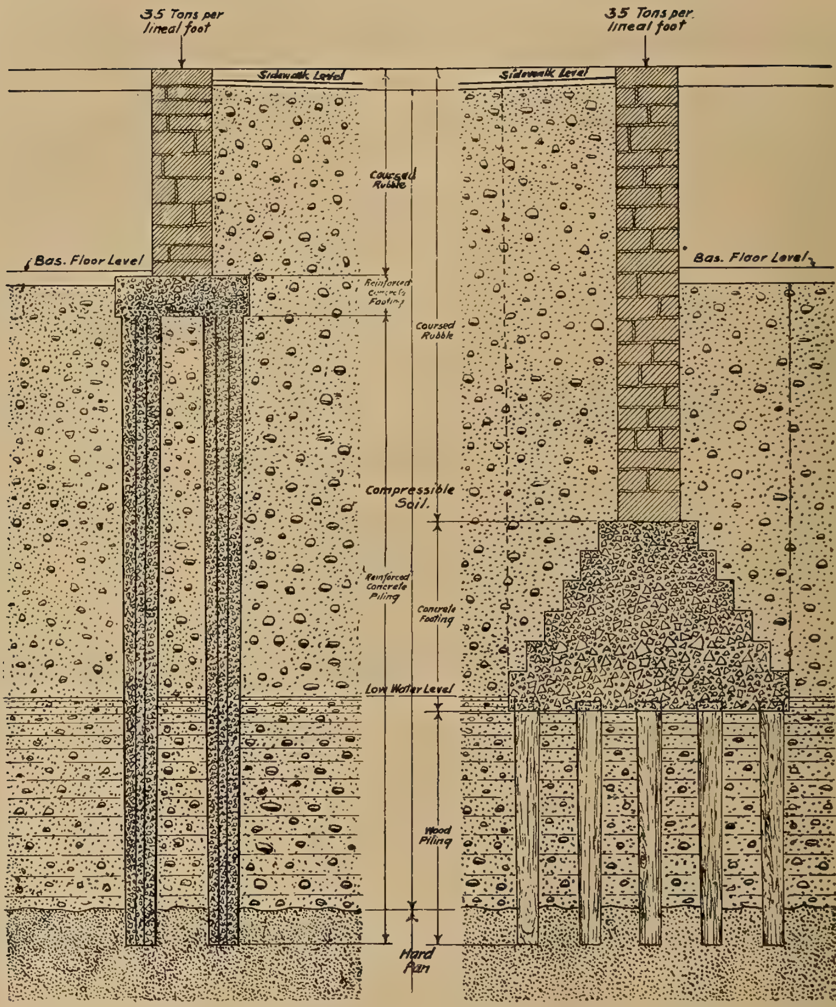
The wooden pile is of very ancient origin. No one can say with any certainty when the first was driven or where. The prehistoric Lake dweller in Europe used wooden piles as supports for their homes. To-day the pile is used everywhere throughout the civilized world. Of course, everyone desires to build upon rock—bed-rock—but there are many situations, otherwise desirable, where such a procedure is impossible on account of the expense, or for other reasons absolutely impracticable. In Chicago, Holland, and many other localities, bed-rock is a long way off. The pneumatic caisson is a thoroughly practical method of reaching solid rock. But it has its limitations. As the caisson sinks below the water-level, the pressure of the contained air must be continually increased. As this augmentation of pressure goes on at the rate of an additional atmosphere for every 34 feet, it will be seen that if the rock is very far off the pressure will soon get beyond the endurance of the workmen. If, instead of piling, the pier built up by the pneumatic caisson procedure had been used for the sea-wall at Annapolis described in the article on "Recent Examples of Concrete Construction" in the July issue, it would have been necessary to carry on a portion of the excavation at the depth of about 190 feet. It would have been necessary for workmen to endure a pressure of more than five atmospheres. There is, of course, the open-air cofferdam procedure. If, however, the soil is water-bearing, it may become impracticable. Moreover, both methods are expensive. And so in many cases it comes about that no attempt is made to reach the underlying bed-rock. Piles are sunk until they have reached hard soil, or until the skin friction has supplied an adequate load-carrying power. There are many cases where the constructors do not cherish any illusions to the effect that the piles upon which they have built are acting as pillars which have secured a footing below. And if other conditions are right, they apprehend no trouble, relying upon the friction of a multitude of piles. If the soil is uniform over the building site, and if the loading can be well distributed, the expectation of a gradual settlement, even if continuous, is not necessarily a prohibitive factor. Of course, the ideal foundation is perfectly unyielding and to be preferred if attainable.

The wooden pile has proved it-

self a very reliable support—subject, however, to certain well-ascertained limitations. In the first place, the surrounding soil must not be subject to easy lateral displacement, otherwise the pile is liable to lose its vertical position and become useless as a support. This requirement of lateral resistance applies, however, to piles in general, whether wooden or not. It may, perhaps, be obviated to some extent by tying them together in groups. Sand is a very good soil for piles, supplying the needed resistance to lateral displacement. Ordinary mud, on the other hand, is practically impossible. In the second place, the wooden pile must be forever wet. Where the entire length is below the water-level, the life of such a pile is long. However, where the upper end becomes exposed to weather changes, deterioration sets in. It has happened that buildings have been constructed with the whole length of the pile below the water-line at the time of erection, but which have later been threatened with collapse on account of a shift of the water-level to a lower point. Thus in New Orleans the drainage consequent upon sewer construction has had the effect of subjecting certain foundation piles to the perils of the dry condition. Of course, relief may be had by arranging for an artificial wetting. But this is troublesome and liable to some failure through inadvertence. If forever wet and not exposed to the attacks of the teredo and other boring animals, which infest certain marine localities, the wooden pile is an excellent support. Protection from the teredo and his friends may be secured by surrounding the pile with sand. Or, it may sometimes be otherwise sheathed. Failing protection, however, the wooden pile may have an exceedingly short life.

Into the field, thus imperfectly covered by the wooden pile, the concrete substitute has entered. Although this invasion has been a matter of merely a trifling number of years, the concrete pile to-day is regarded as a demonstrated success. Perhaps most engineers conversant with both classes would say that, upon the whole, concrete piling is to be regarded as decidedly superior. It is not a necessity that these piles be forever submerged. The pile may be exposed upon its upper end to the atmosphere. If the concrete, however, is to be subjected to the alternately-freezing-and-thawing action of water, it must be made waterproof where so exposed. On account of the indifference of the concrete pile to hydraulic conditions, it often has even a first-cost superiority to the wooden one. To illustrate this point we may refer to a typical case which occurred in St. Louis some few years ago. A large building was to be erected on a spot where the low-water level was 12 feet below the floor of the cellar. The deep foundations which would have been necessary if some descrip-

ACTION OF TEREDO ON WOODEN PILES



COMPARISON OF FOUNDATIONS ON WOODEN AND CONCRETE PILES

tion of piling were not used were too expensive, so that it became a question between wooden and concrete piles. To secure the necessary supporting ability more wooden piles would have had to be driven than if concrete piles were used. The mere comparative expense of cost of material and cost of driving was scarcely decisive. The controlling factor depended largely on attendant considerations. By examining the above cut these will become plain. The construction shown on the right is typical of that required by the use of wooden piles. In the first place, their heads must be below the water-level line. They must, therefore, be cut off in accordance with this requirement. Next, a footing must be constructed, with a base wide enough to cover the increased number of piles. Further, the wall must be carried down to a point below the cellar floor to meet the upper surface of the concrete footing. It will readily be seen that if we take these requirements into consideration, excavation to the full width of the base of the footing would have to be carried down below the low-level line. This would have involved expense

CASTING GILBRETH CONCRETE PILES. THE REINFORCEMENT IS VISIBLE IN THE OPEN MOLDS

for removal of material, sheet-piling to retain the surrounding soil, possibly pumping to keep the trench clear of water, and finally the refilling of a large portion of the excavation. With concrete piling the case is far different, as may be seen in the left-hand portion of the illustration. Here there would be no necessity for sawing off, no deep-sunk and wide footing. There is a trifling excavation for a narrow footing. The wall terminates at the cellar floor. When, in addition to conditions affecting first cost, we bear in mind that the owner would not have to be forever on the alert—as in such cases would often happen

METHOD OF CUTTING OFF A GILBRETH CONCRETE PILE. THE CONCRETE IS CUT AWAY AND THE REINFORCING RODS SAWED OFF

—to know whether the low-water level were subsiding or not, it is not hard to see that the concrete pile is bound to displace the wooden one under circumstances similar to those described.

The teredo does not care for concrete, so no protective measures need be adopted on its account. Almost the only question that arises concerns the condition of the pile shortly after it is placed in position. If its form is still perfect and the structure of the concrete unimpaired, we may confidently regard it as almost the ideal thing. Indestructible, capable of great compressive resistance, economical as to first cost, the perfect concrete pile has come to stay. The eight years of experience in the United States with piles made of concrete would seem to justify the assertion that it is now no longer a question whether they are to become standard practice, but which is the best procedure to adopt as to their construction and placement.

There are two rival procedures. According to the one, the pile is completely formed above ground and then put in place. According to the other, the pile is constructed or cast in the ground. As representative of the former method may be cited the Hennibique, the Chenoweth and the corrugated piles. Examples of the process of casting in position are the Raymond and the Simplex systems.

THE CORRUGATED PILE.

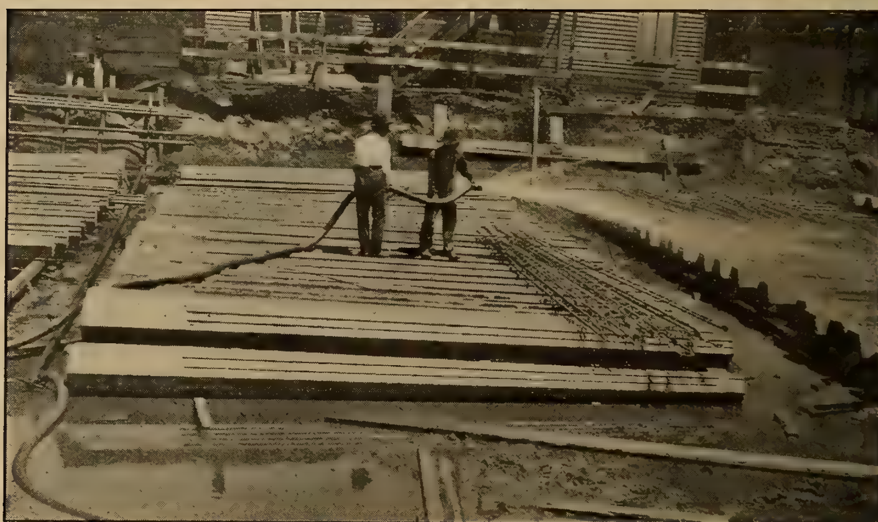
This pile derives its name from the longitudinal ridges or corrugations which extend nearly the whole length of its exterior surface. There are thus a series of longitudinal grooves. Their office will become apparent as we proceed. Along the axis of the pile a hole is arranged. This perforation extends the entire length. It might be thought grooves and perforations would weaken the pile. But this would be rather an unfair way to look at the question. We must not compare a perforated and corrugated pile having a given

WITHDRAWING A CORE FROM GILBRETH CONCRETE PILE

TAMPING THE MOULDS IN MAKING GILBRETH CORRUGATED PILES

external size with a solid and smooth one of the same external dimensions. It would seem to be only just to compare weight with weight. Looked at from this point of view, there can scarcely be any question but that the system of corrugated piles controlled by Frank E. Gilbreth of New York City is stronger than a plan pile of the same weight of concrete. There is a further advantage — the corrugations increase the amount of contact with the surrounding soil and so augment the skin friction and the consequent supporting ability. Further, if the perforation be regarded as an objection, it may readily be filled with concrete or cement mortar upon the conclusion of the driving operation. This pile is completely formed before it is placed in position. Long horizontal molds are used. Apart from the grooves the form is pyramidal, with the taper gentle. Suitable ridges are arranged in the mold to form the grooves in the finished pile. The one groove at the top, however, may be formed by hand. A wooden rod is used to mold the perforation. At a suitable moment this rod is withdrawn. This withdrawal must, however, not be deferred too long. With the pile formed and partially hardened it may be placed to one side to mature. This gives opportunity to promote the hardening of the concrete by spraying.

It will thus be seen that the Gilbreth pile may be thoroughly matured before any attempt is made to place it in position. This is the great advantage possessed by those systems which first cast, then place the pile. The pile used is then a very thoroughly known article. There is no doubt that this is a capital point. It is subject to some modification, however. The pile on top of ground and the pile in position may be two very different things. The intervening operations are handling and driving. Either or both may operate disadvantageously. Concrete has two considerable weaknesses. Its tensile strength and its resistance to shear are both quite small in amount. That is to say, cohesion is inconsiderable. And so, the transportation of a pile of simple concrete may produce internal ruptures. If the pile is driven by the ordinary procedure of dropping a weight, still more serious results may conceivably

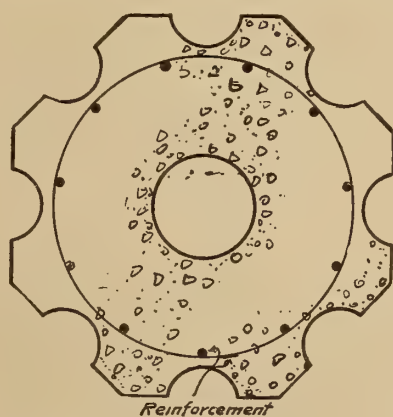


SPRAYING CONCRETE PILES DURING THE MATURING PERIOD

occur. But in concrete piles, as in other concrete structures, the want of cohesion may be largely supplied by means of steel reinforcement. In the case of the Gilbreth pile, formed as it is on top of ground, the reinforcement may be very accurately placed. Unconnected longitudinal rods arranged in a ring near the outer surface of the pile may be used. Or these may be bound together by circumferential wires. Or a welded fabric may be employed. That a proper system of reinforcement is fully competent to render the pile immune to damage from handling seems quite clear. Further, many reinforced piles have been forcibly driven, and with a good deal of success. However, it is at this point that the central perforation of the Gilbreth pile finds its especial application. In very many locations where piles may be driven at all, it is possible to use the water-jet to advantage, either for facilitating the driving or for accomplishing practically the whole of the soil-piercing operation. In accordance with the Gilbreth system, a pipe or hose conducts a current of water down through the central hole to the foot of the pile. Gravel, sand and loam may all be dealt with by the hydraulic jet there formed. The material is washed away from the foot and carried with the return current up the external longitudinal grooves to the surface.

Opposite is shown a typical cross-section of a Gilbreth pile. The arrangement of the reinforcement is likewise disclosed. The hole in the center varied, having been 3½ inches at the top of the pile and tapering to 2 inches at the bottom. This form of hole is advantageous in permitting more concrete to be used than if a uniform hole of larger diameter were made. Further, it facilitated the withdrawal of the core subsequent to casting.

In driving the Gilbreth corrugated pile, the water-jet may, at times, be used almost exclusively to effect penetration. It carries the material away from the advancing point and brings it up the grooves. Light driving with the hammer may be used concurrently with the jet. However, corrugated piles may sometimes be driven by the hammer alone. Of course, some arrangement for cushioning the blows of the hammer will be employed. Even in cases where the jet is mainly relied on, it is advised to withdraw it from use when the last foot of penetration is to be accomplished and to effect this final operation with the hammer alone. It may sometimes happen that, when using both hammer and

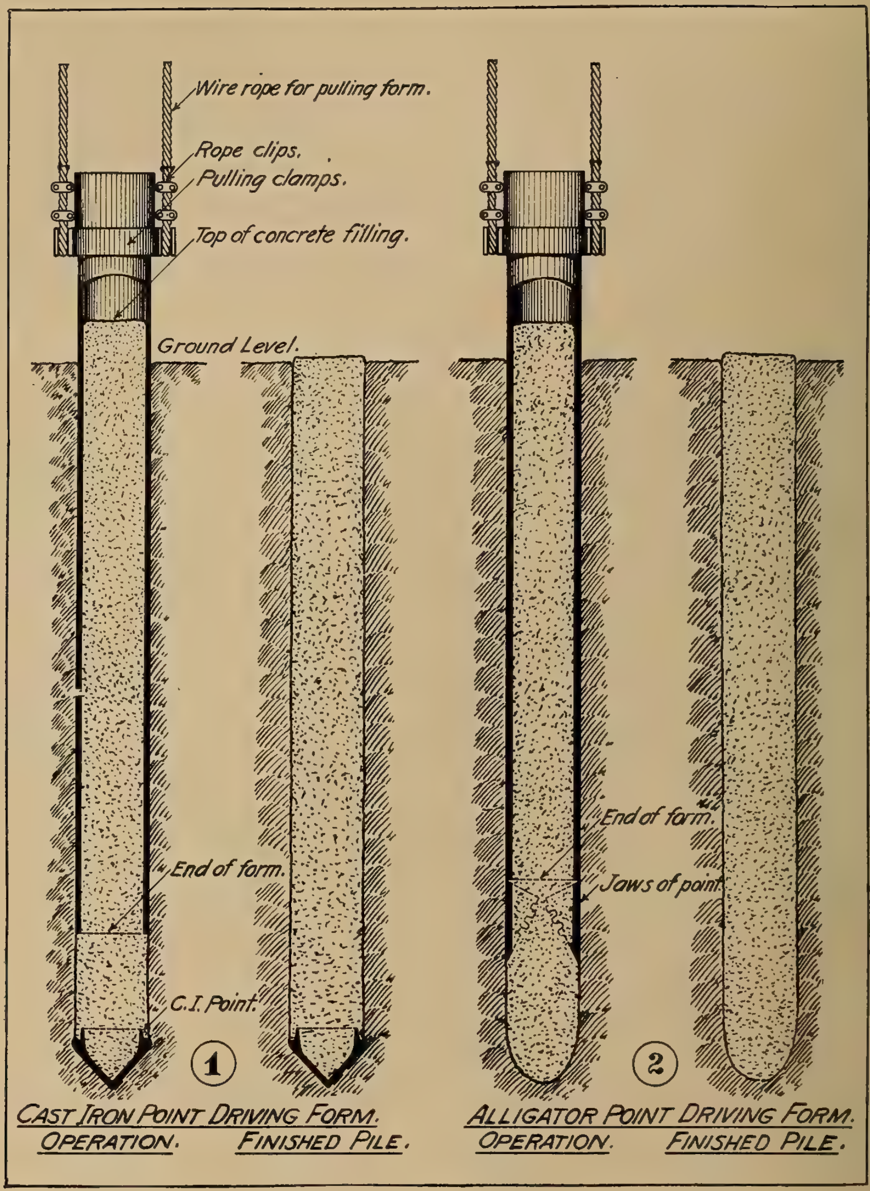


SECTION OF GILBRETH CORRUGATED PILE

jet, the hammer will advance the pile faster than the jet removes the material. This should be at once corrected, not only because there is insufficient room between the jet pipe and the interior of the pile, but because it has been found—so it is claimed—that the process of exhausting the water externally increases the skin friction.

THE SIMPLEX PILE.

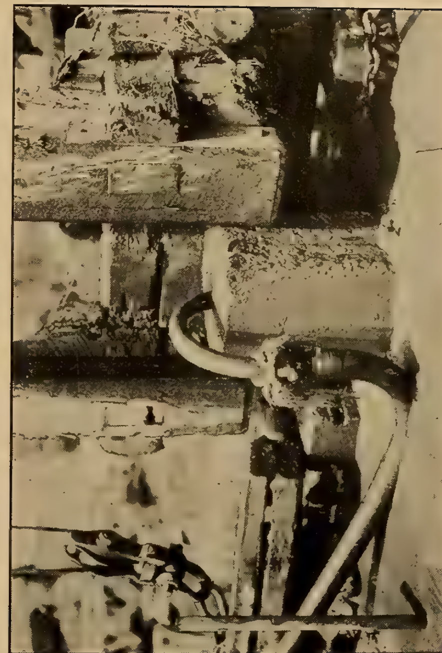
All systems of concrete piling are recent. And that of the Simplex Concrete Piling Co., Tacony, Philadelphia, Pa., is no exception, dating from about 1903. Their piles are formed in position and are not driven. With the Raymond system,



CONSTRUCTION OF THE TWO TYPES OF SIMPLEX CONCRETE PILE

the sheath which is used to prevent the collapse of the surrounding soil is left in the ground. With the Simplex system it is withdrawn at the time of casting. This method has had its period of development—just as the case is with pretty much everything of value. At first an ordinary wooden pile was driven into the ground, then withdrawn, and the cavity filled with concrete. Soon a solid steel form was used instead. The next step which marked the developing system was the use of steel tubing. And this was apparently a finality, for the tube is still employed. In order to provide a driving point, one was constructed of re-

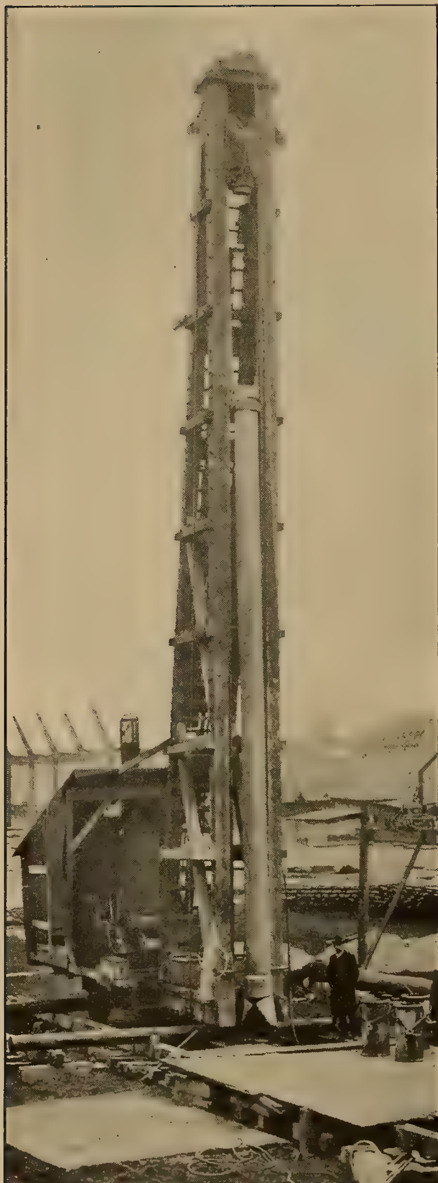
REINFORCEMENT OF FOOTING SUPPORTED ON CONCRETE PILES



GILBRETH CONCRETE PILE ALMOST DRIVEN

FOOTING OF FOUR GILBRETH PILES, SHOWING THE REINFORCEMENT RODS

THE COMPLETED CONCRETE FOOTING



ALLIGATOR FORM OF SIMPLEX PILE CASING WITH JAWS OPEN

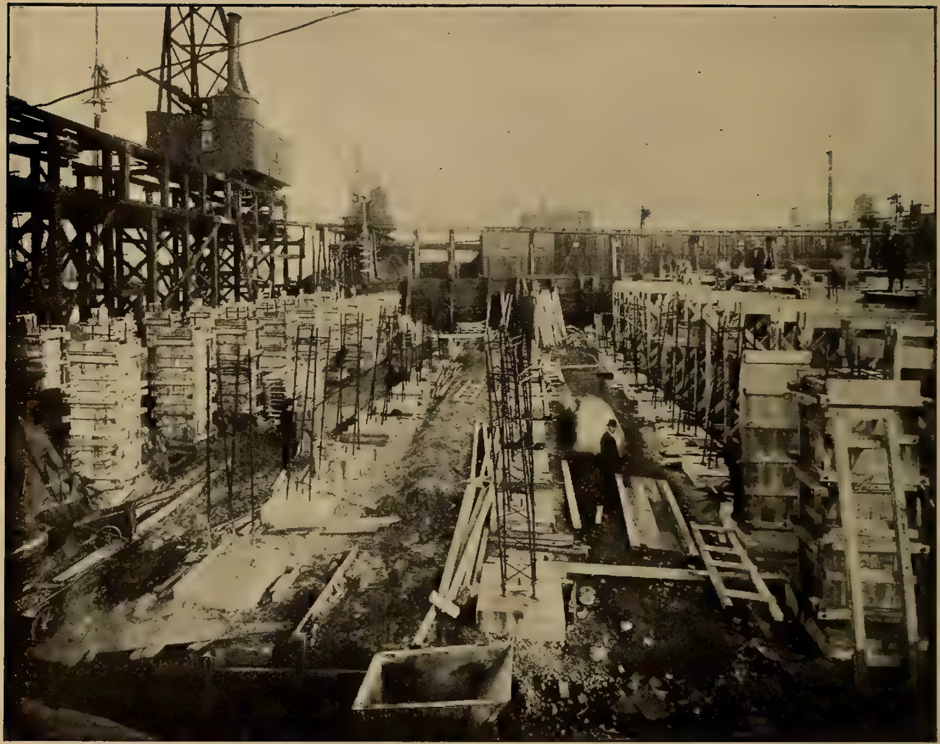
inforced concrete, conical upon one side and having a shoulder on the other. The bottom of the steel tube rested against this shoulder, the whole forming a kind of hollow pile with a pointed end. Upon reaching final position, concrete was poured into the tube and the latter withdrawn, leaving a complete concrete pile in the earth. Later, it was found advantageous to use a cast-iron point instead of the one of concrete. This was in the form of a conical shell. Both methods are practical. It would seem, however, that the concrete point is to be preferred, as apparently the cast iron could not long resist corrosion. However, both are now being superseded by a point attached to the steel tube and withdrawable with it. Two pieces of steel are hinged at the lower end of the tube and at opposite ends of a diameter. When closed upon each other they form a chisel-like point. When open they are mere continuations of the walls of the tube. The former position is automatically kept during the driving operation, while withdrawal at once permits the "jaws" to open. In practice, however, this opening is actually compelled by the pressure of the concrete. The advantage of this style of point is that it obviates the necessity of carrying a stock of cast-iron or concrete points. It seems probable, too, that it permits a more secure footing for the pile, as the concrete, when forced out of the end of the tube, is free to adapt itself to the form of space it finds. The negroes who were the first workmen engaged in using it nicknamed it the "alligator" point. And this name has been acquiesced in by the company. By referring to the accompanying diagram, p. 434, the system, as applied with the cast-iron point and with the alligator point, will be readily understood. Upon the extreme left is seen at the bottom the cast-iron point. The steel tube is plainly seen, but separated somewhat from the point. This is because the concrete is being rammed home and the tube withdrawn. These operations are performed simultaneously. The next figure shows the completed pile, with all the concrete rammed into place, sufficient material having been used to compensate for the withdrawal of

SIMPLEX PILE PARTLY EXCAVATED, SHOWING COMPRESSION OF EARTH

It will readily be understood that a tube subjected repeatedly to the impacts of the driving hammer at one end and to the resistance set up at the other would need very substantial reinforcement. To supply this at the upper end, a band of boiler steel, one-half inch in thickness and 18 inches wide, is riveted on the outside. The rivets used are heavy and there are three rows of eight in a row. Even with this heavy reinforcement the tube is found to be none too strong. There are four good-sized holes arranged around the circumference to accommodate the pins used to provide a means of operating the pulling

SIMPLEX PILE REMOVED FOR INSPECTION

the sheath of metal one-half inch thick. The cast-iron point is seen at the bottom. The third view discloses the alligator form of apparatus in process of removal. Concurrently with this withdrawal, the concrete is forced to occupy the space available. Ordinarily we may expect the footing of the pile to be blunter under these conditions, and consequently capable of supporting a heavier load. The final view shows the completed pile, all the concrete having been forced into place. The foot is blunt and there is no metal toe to corrode and, perhaps, yield under a disintegrating process.



CONSTRUCTION OF 10,000-TON COAL POCKET FOR THE LEHIGH & WILKESBARRE COAL CO., CHARLESTOWN, MASS. FOOTINGS CARRIED ON SIMPLEX CONCRETE PILES

shackle. To reinforce the lower end, a cast-steel tube of the same internal diameter as the sheath and one and one-half inches thick is counterbored to the depth of eight inches to receive the sheath. These are then riveted together with one-inch rivets, twenty-four in number. The alligator point is attached at the lower end. No bolts are permitted anywhere. The sheath and open alligator jaws have an internal diameter of fourteen inches. The length of such a driving form made from a stock length (about twenty feet) of pipe would be about twenty-two feet. In case it is desired to use a longer form, two sections of pipe may be joined by an envelope of one-half-inch boiler plate riveted to both sections.

Although the Simplex pile is not driven, a pile-driver is used to force the steel tube into the ground. Further, the machine must be entirely arranged to enable this form to be withdrawn. The apparatus is, accordingly, built in a very substantial manner. In order to cast a concrete pile by this system the driving form, with, say, the alligator point, is placed in position. The jaws are now held together by a pin. But when driving is about to begin and the point is already a few inches in the ground, the pin is removed. The jaws are now and afterwards held in driving position by the external pressure against them. A steel-driving head is arranged at the upper end of the form. This head has a projecting tenon below, with which engagement with the tube is secured. The blows of the hammer are not delivered to this head immediately, but through an intervening block of wood. The purpose of this is to cushion the impact. The

form is now driven to the desired depth. The hammer, block and driving head are then raised to the top of the leads, and necessary arrangements made for drawing the form. A cast-iron weight, six inches in diameter and about three feet in length, is then lowered to the bottom and a target fixed in the rope to mark the point corresponding to the top of the form. This measurement completed, this three-hundred-pound weight is raised half-way up the tube and a bucketful of concrete dropped past it. A special bucket, with a falling bottom, is used. The weight is now lowered until it rests on the concrete. The target will be some distance above the top of the form, its position corresponding to the amount of concrete in place. Withdrawal of the form now begins, but is stopped when the position of the target indicates that the weight is within about a foot of the bottom. Such a position means that the jaws have opened and that there is a quantity of concrete at the bottom of the form, preventing the intrusion of the soil. Ramming the concrete is accomplished by raising and lowering the weight. When it seems clear that this has been well done, the weight is again elevated and a second bucketful of concrete dropped in. The form is again pulled and the concrete rammed. In this way the entire pile is cast by alternately pouring and drawing. When at last the alligator point comes into view, it will probably be found to be well clogged. The concrete and the mud are, however, readily removed by a steam-jet. This cleaning operation is a necessary preliminary to driving the form for another pile. In carrying on the process of casting piles, it is not always necessary to fill in but a single bucketful at a time. Often the entire pile has been cast before withdrawal of the form.

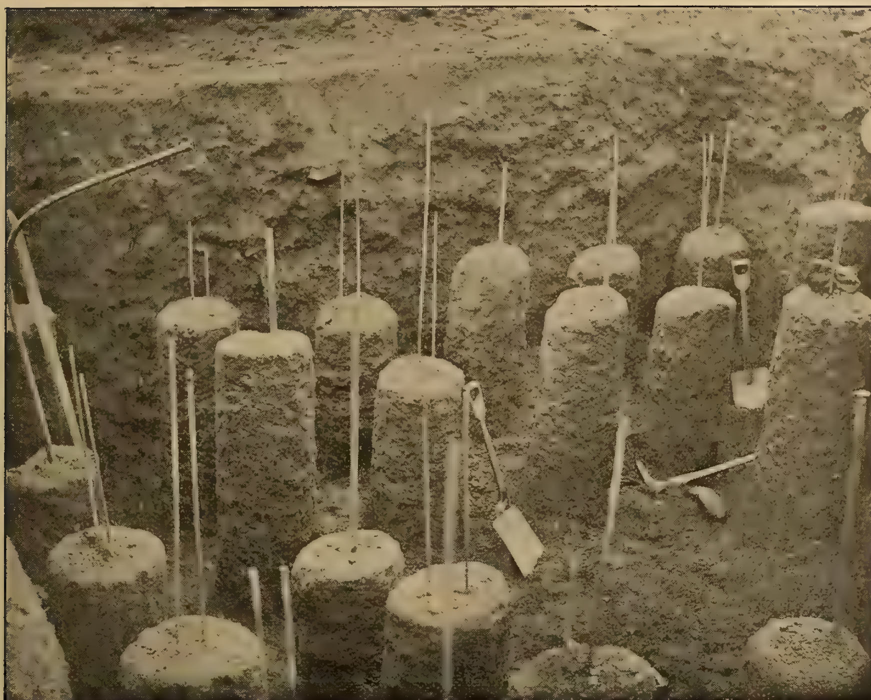
It will readily be seen that the

COAL POCKET OF 10,000 TONS CAPACITY AT CHARLESTOWN, MASS., SUPPORTED ON SIMPLEX CONCRETE PILES

TWO SIMPLEX CONCRETE PILES 25 FEET LONG, COMPLETELY EXPOSED FROM TOP TO BOTTOM, SHOWING THEIR PERFECT CONDITION

The Foundation of the Heat, Light, and Power Plant for the United States Capitol and Congressional Library at Washington, D. C., contains 800 of these piles.

Simplex pile will often be quite irregular on its lateral surface. This is due to the fact that the ramming process is effective not only in forcing the concrete downwards but also transversely. The effect, then, is to fill in the natural irregularities of the surrounding earth. There is, however, a tendency which may militate against the effort of the concrete to form a somewhat expanded pile. In forcing down the steel form a considerable amount of earth is necessarily displaced. Conditions may easily be such that this displacement will give rise—upon withdrawal of the form—to a tendency to resume the original position. Ordinarily, this would be fully met, no doubt, by the presence of the setting concrete, assisted by the ramming. But we can readily conceive that the elasticity of the surrounding strata may not be everywhere the same,



AN EXPOSED NEST OF SIMPLEX CONCRETE PILES

and that in consequence a very strong constrictive tendency may be localized at points along the line of penetration. This might, of course, result in a serious reduction of the diameter of the pile at one or more points. The remedy would appear to be plain. Let the concrete be filled in little by little, and follow closely any change in level that takes place in the target. Unless strong constriction should occur in close proximity to non-resistance, the position of the target could, perhaps, be relied on to indicate any serious closing in of a stratum. If this be regarded as not thoroughgoing enough, on account of want of sensitiveness of the indicator, then, perhaps, a more reliable remedy would be to put the concrete continuously under a pressure sufficient to make a certainty of successful resistance to any constrictive effort of the soil.

(To be Concluded.)

THE MASS BALANCING OF STEAM-TURBINE ROTORS

By W. H. Heaton, M. Inst. M. E., M. Inst. E. E.

IN general, the absence of vibration is a noticeable characteristic in the operation of steam turbines, and probably this feature has contributed in no small measure to the development and increasing adoption to this type of prime mover.

With piston engines having unbalanced reciprocating masses, particularly engines with short connecting rods, it is impossible to obtain perfect balance as regards all the inertia forces, and in practice a compromise is adopted, and some vibration must be endured. On the other hand, the steam turbine is fundamentally different. The blading is subjected to a constant turning effort, and with full peripheral admission it is uniformly distributed around the entire circumference of the blade wheel; consequently, steadiness of running is an inherent characteristic. A vibratory operation is representative of an abnormal condition—invariably arising from an imperfect mass balancing of a turbine rotor—and is made evident by a more or less suppressed pounding action at the bearings, which communicates a tremulous movement along the pedestals and throughout the entire machine.

Another consideration, quite apart from the vibratory condition, emphasizes, not merely the importance, but the necessity, from an essential aspect, of according to the question of mass balancing the revolving element of a steam turbine the fullest measure of appreciation. Applied to turbines of the reaction type, the radial clearance of the blading (*i. e.*, a dimension of the annulas between the periphery of the table ring and the adjoining part, measured radially) and steam economy are mutually convertible terms, and as the mass balance of the rotor is an influential factor towards determining the minimum clearance values consistent with the avoidance of peripheral contact of the blading, the significance of the balancing of rotors is not easy to overestimate.

Steam turbine rotors consist of an assemblage of separately machined parts symmetrically united about the axis of the shafting, and the errors of the balance are those emanating from the lack of symmetry. The balancing of a rotor resolves itself into correcting this lack of symmetry of, speaking more accurately, compensating for a "free weight" which the unsymmetrical conditions involve. The essence of the proposition lies in a double process (a) locating the position or positions of the "free weight," (b) attaching compensating weights to perfect the mass balance about the axis of rotation.

It is, of course, necessary to have a pair of reliable balancing ways. A form of construction that has become general, and with skilful usage adaptable to procure excellent results, comprises a pair of rectangular treads or slabs of mild steel, with plain machined surfaces, preferably ground to a finish. It is imperative that the upper side of each tread is furnished with a continuously smooth surface from end to end, and the effective length should not be less than equal to the distance traversed in two complete revolutions of the turbine shafting. The combined width, compared with the total weight of the rotor, should be such that the actual load

supported does not exceed 3,000 pounds per lineal inch of tread. It is convenient to mount each tread on upright cast-iron bearers, and the feet of the bearers are usually provided with adjusting screws that rest on sole plates, supported on foundations, absolutely proof against deflection when loaded. Guard plates, to prevent the rotor overtraveling the treads, complete the construction. The balancing ways should be arranged parallel to each other, and separated by a distance something like equal to the axial distance between the centers of the journals of the turbine shafting, and it is exceedingly important that the upper surface of each tread is adjusted to the same horizontal plane, for upon this feature the accurate balancing of the turbine rotor is substantially dependent.

A methodical commencement of the actual balancing process begins by placing the turbine rotor centrally, or, in other words, locating each shaft in a mid position across the ways, and subsequently causing the rotor to roll slowly, traveling, say, in a forward direction until it arrives unaided in a resting position. It is useful to repeat this operation with the direction of travel reversed. Assuming a typical example, the final resting place of the rotor is the same, irrespective of the direction of rotation.

These operations have determined the positions of the "free weight," or what corresponds to the heavy side of the rotor, and which obviously lies vertically below the axial line of support. For subsequent identification it is desirable to chalk-mark the rotor at this point and attach compensating weights diametrically opposite, for which purpose a standard construction provides studs, screwed in the end discs, and pitched at equal intervals apart, on a circle struck from the shaft center. The actual amount of weight necessary to compensate the heavy side is determinable only by trial and experiment, but some familiarity with the work, particularly in the way of closely observing the behaviour of the rotor approaching the resting position, is invaluable towards promoting a proficiency to correctly estimate the requisite compensating weight.

In any case, the rotor starting from either end is rolled again by a series of forward impulses, which alternate with the rotor stopping dead as the impulses become exhausted, after which, moving in the opposite direction, the process is repeated to the original starting point. Some indication of the counsel of perfection attained in the balancing of the rotor is derivable from this experiment. If, for example, the actual stopping of the rotor is preceded by oscillatory movements, on one or both sides of the final resting position, the motion indicates an unstable equilibrium, commensurate to the degree of excellence of balance so far obtained. The swinging motion originates, and is wholly attributable to, the "free weight," not yet compensated. For perfect balance, the stopping positions of the rotor are definitely fixed, occurring only when individual turning impulses are spent in work of displacing the rotor, and for equal impulses the horizontal travel of the shafting along the ways is the same.

The efficiency of the work of balancing a turbine rotor may be finally established by another test, after reversing the rotor, end for end, on the ways. A repetition of the previous observations, relating to the behaviour of the rotor, confirms the accuracy of the work executed, but, in addition to this, changing the position of the rotor in the manner described affords a means of revealing possible errors in the alignment of the ways. From this standpoint the procedure is recommended.

As to what has been actually accomplished in the case of mass balancing of a turbine rotor, and which exemplifies the practical utility of the general principles underlying the static method, it may be of interest

to record the following particulars. The total weight of a balanced rotor forming the revolving element of a divided-flow 7,500-horse-power turbine, assembled complete, with blading, slightly exceeded 45,000 pounds. The diameter of the pitch circle of the studs, by which the compensating weights are secured, was exactly 70 inches. With the rotor lying momentarily in a resting position, but free to travel, the weight of an ordinary 1½-inch washer temporarily suspended to a stud in a position normal to the shaft axis proved sufficient to start the rotor rolling from rest and cause displacement through 90 degrees. The commercial operation of the rotor in an assembled turbine admirably fulfilled the anticipations of the manufacture. A critical examination of the machine failed to discern any appreciable tremor, and this to a point of excellence that an ordinary pencil some 8 inches long remained erect in an end-on position when poised on the bearing housings, enclosing the journals of the rotor shafting.

The facts previously enumerated exclusively concern the mass balancing of a rotor statically. Another method, having the same objective, consists in utilizing a scriber point, suitably adjusted in a fixed position, to mark the rotor circumferentially when revolving at the normal full speed. The principle thus involved assumes an eccentricity of rotation, and the line described is, therefore, continuous. Upon this characteristic all the essential information for subsequent guidance towards procuring the mass balance is derived.

The process is, however, slow, costly, and tedious, and the knowledge acquired from a practical association with both methods does not inspire the conviction that the static method is less advantageous, from the point of view of accuracy, provided the normal speed of rotation is somewhat below the critical velocity.

A not inconsiderable experience with the practice of operating steam turbines crystallizes the opinion that a rotor in service will preserve for an indefinite period a balance not materially impaired, providing the operating conditions are reasonably normal. A contingent disturbance, however, precisely analogous in effect to that which accompanies the operation of a defectively balanced rotor, arises from the propagation of slugs of water through a turbine served with boilers priming intermittently. A broad explanation of the phenomena assumes that the axis of rotation is suddenly and temporarily displaced in space equivalent to supposing a momentary translation of the rotating mass relatively to the cylinder. The statement is seemingly consistent with the facts observed, because the vibration thus occasioned subsides gradually, and the normal operation restored at a measurable interval of time subsequently to extinguishing the disturbing causes.

For this reason, and not so much on the supposition of avoiding the differential expansion of the stationary and revolving parts, it is prudent to condemn the senseless practice of suddenly raising to full speed a turbine started from rest, unless the exigent circumstances prevail, because water-logging the interior of an active turbine with the accumulated condensation of the main steam line—a contingency more or less unavoidable in many otherwise excellent steam-pipe systems—is intimately correlated to the stripping of blades, particularly with multiple expansion pressure compound turbines.

RECENT DEVELOPMENTS IN LARGE GAS-ENGINE DESIGN

By Percy R. Allen

III.—TWO-CYCLE ENGINES

In previous articles Mr. Allen has discussed the development in the design and construction of large gas engines of the four-cycle type, including British, Continental, and American practice. The present paper, closing the series, treats of the extent to which the two-cycle system has been developed for large engines, the series thus covering the subject very fully down to the present.—The Editor.

DURING the period that the four-stroke Otto cycle arrangement was protected by patent rights the high prices obtained for such engines and the heavy royalties demanded from licensees acted as a strong stimulus to inventors to design gas engines operated in a manner that could not be construed as an infringement. Mr. James Atkinson was at one time particularly active in suggesting alternative systems and brought out some very original designs, notably the Differential and so-called Cycle-engine. This gentleman ultimately joined Messrs. Crossley Bros., and for some years the Otto cycle-engine held undisputed sway. However, there has always existed a feeling that the two comparatively idle strokes of the Otto cycle might be dispensed with, and as far back as 1880 Mr. Dugald Clerk produced a single-acting, two-cycle engine which is admitted to have embodied the fundamental ideas of the present two-cycle, double-acting Körting engine. In fact, Mr. Ernest Körting, when he took the matter in hand, seems to have treated Clerk's ideas in much the same way as Otto did those of Beau de Rochas; that is, introduced the necessary modifications to make the machine a commercial success. In point of date the Oechelhäuser two-cycle engine was a little before the Körting engine, as the first Oechelhäuser engine of 600 horse-power was set to work at the Hoerde Steel Works in 1898; but for the sake of convenience it may be advisable to describe the Körting system and its modifications before dealing with the Oechelhäuser engine.

The underlying idea of both systems is that if it were possible to get rid of the exhaust without having to sweep it back through the cylinder with the return of the piston and at the same time to introduce a charge of mixture from some exterior source into the cylinder two of the strokes might be done without, and the cycle would then be simplified so that it only consisted of the two strokes, the first one utilizing the force due to the explosion and the second, or return stroke, compressing the charge ready for firing next time. Thus a single-acting gas engine constructed in this manner would have the same number of impulses as a single-acting steam engine, and a double-acting, two-cycle engine would, as far as impulses go, be in the same condition as a double-acting steam engine. The arrangement of air and gas pumps necessary to introduce the change and the valve gear connected with them has been considerably modified of recent years by the various licensees of the Körting patents; but the conventional diagram of the original arrangement shown in Figs. 1 and 2

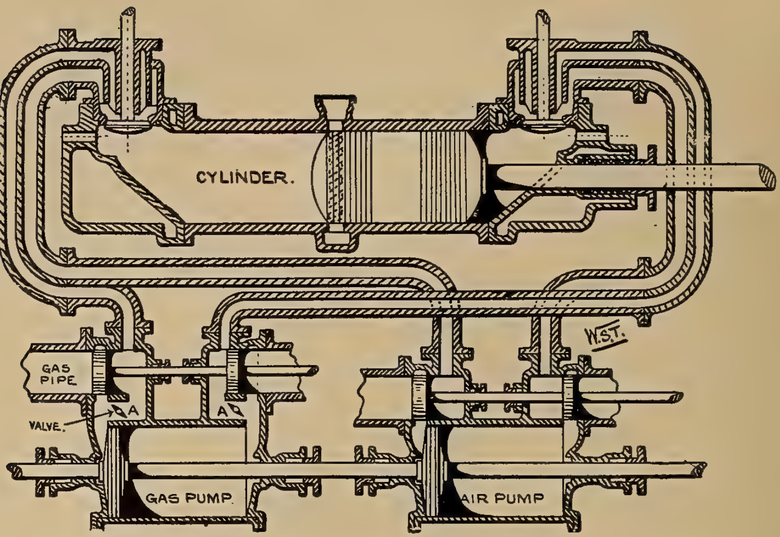


FIG. 1.—CHARGING PUMPS AND VALVE GEAR OF THE KOERTING TWO-CYCLE ENGINE

explain very well the general arrangements, and, if properly comprehended, will enable the subsequent modifications to be better understood.

In a double-acting, two-cycle engine the exhaust ports are placed in a ring in the centre of the cylinder, and a long piston is employed, which, just before the end of the stroke, uncovers these ports and allows the spent charge to escape down the exhaust. These ports remain uncovered until the crank has turned the centre, when they are again closed during the early part of the return stroke. During this period the ex-

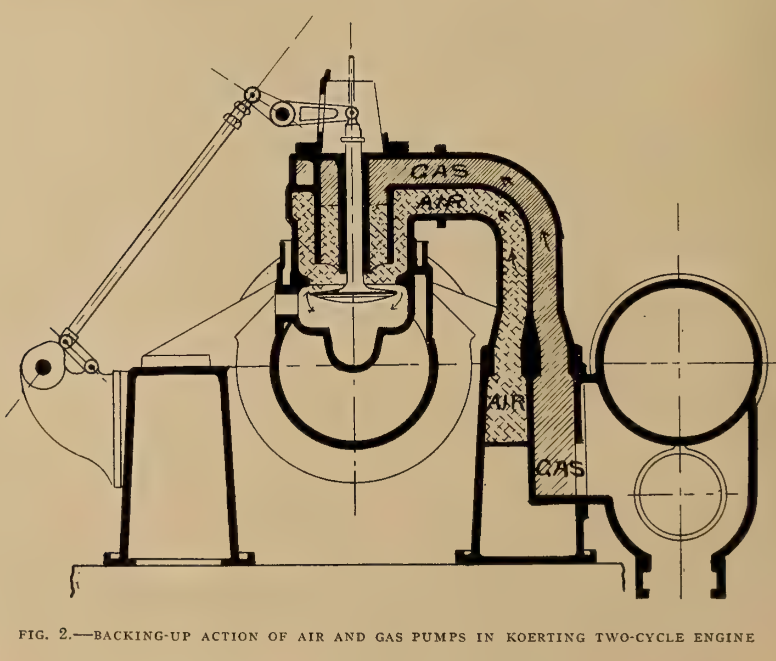


FIG. 2.—BACKING-UP ACTION OF AIR AND GAS PUMPS IN KOERTING TWO-CYCLE ENGINE

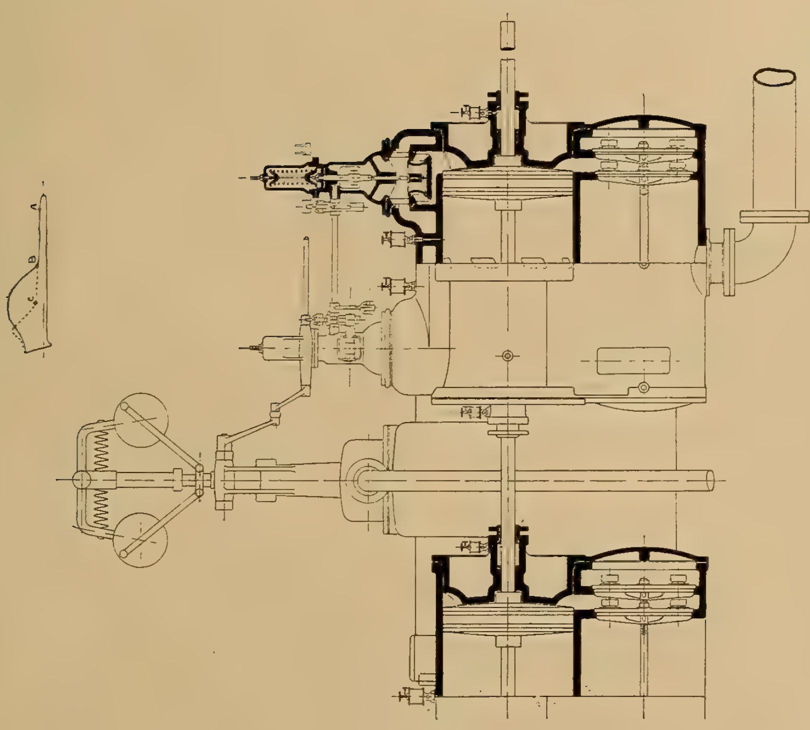


FIG. 3.—LONGITUDINAL VIEW OF GAS PUMP AND GOVERNOR ON KOERTING ENGINE. DE LA VERGNE MACHINE CO., NEW YORK

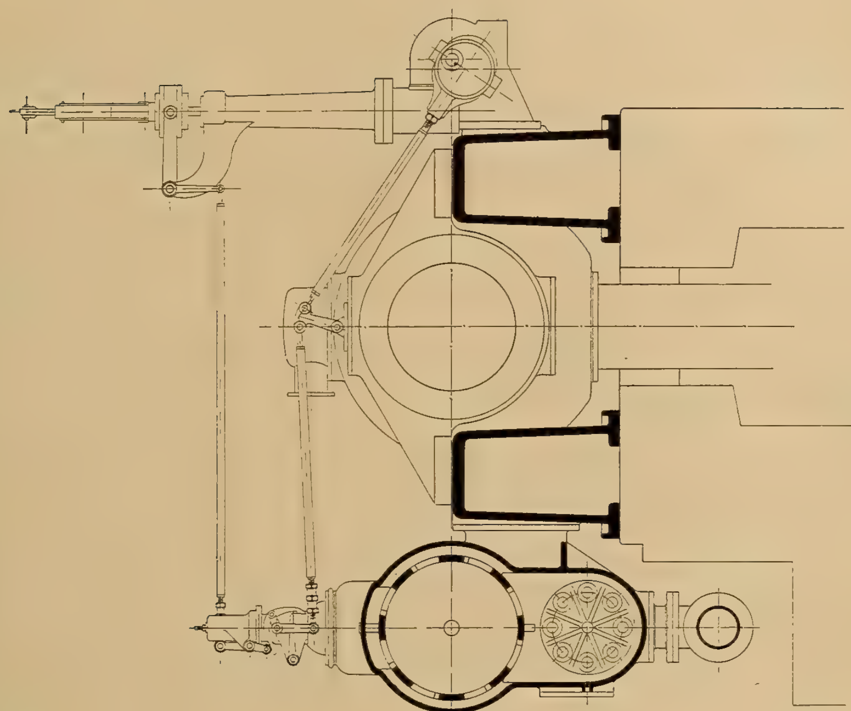


FIG. 4.—TRANSVERSE VIEW OF GOVERNOR, TRIP GEAR, PUMPS, AND CYLINDER ON DE LA VERGNE KOERTING ENGINE

haust has fallen to the atmospheric line, and has been swept out by an advance charge of air, which is entered through the inlet valve just before the body of air and gas forming the mixture. Sufficient mixture is introduced into the cylinder by the superior pressure produced by the air and gas pumps, and then when the inlet valve closes, as the exhaust ports are already shut, the charge of mixture is imprisoned in the cylinder and compression takes place in the ordinary way, due to the return of the piston. Two pumps are used to form the charge, one a gas pump and the other an air pump, and for the sake of convenience these are generally arranged horizontally and parallel to the main cylinder. The piston rod common to the air and gas pumps is worked from a crank disc keyed on the end of the main crankshaft. Both pumps naturally have the same stroke, but while the air pump delivers air during the whole of its stroke the gas pump has a variable delivery, and regulation is effected in this manner. The crankpin driving the forcing pump is set at an angle of from 90 to 101 degrees in advance of the main crank, the particular arrangements of different makers determining the exact position. Referring to the early arrangements shown in Fig. 1, which is taken from a published description of the De la Vergne Körting engine, it will be seen from the sketch that the piston is approaching the back end of the power cylinder, while the pump pistons are traveling forward in the direction of the crank end of the engine. It should be mentioned that this illustration does not show the pump pistons in exactly the relative position to the main piston, but the mental correction is easily made.

For 40 per cent. of the compression stroke the gas displaced is merely discharged into the suction channel *c;* after this point the piston valve *p* slides across port *b* and allows the gas for the remaining 60 per cent. of the stroke to pass into the channel terminating at the crank-end poppet valve.

During the 40 per cent. of the pump stroke (air and gas pistons being on the same piston rod, and, therefore, moving together) the air pump discharges its volume of scavenging air into the power cylinder, and for the remaining 60 per cent. of pump stroke keeps on discharging air into the combustion space simultaneously with the gas, and thus forms the combustible mixture. If during this period the governor should act upon the two by pass valves *f*, more or less of the gas in the channel for the back end poppet valve will return through *f* into the suction side of the gas pump, joining the supply of fresh gas from the main, consequently the amount of gas in the channel will be proportionately diminished.

On the return stroke of the gas pump piston (toward the back end), where the first 40 per cent. of stroke is again discharged into the gas suction, as usual, the air pump discharges, as before, and forces the air not only up to the (back end) poppet valve, but further on into the channel ordinarily occupied by gas. When, therefore, the poppet valve opens, the supply of air coming from both the air and the gas channels will be greater, depending upon the amount of gas previously returned by the action of the governor through the gas pump by-passes *f*.

Fig. 2 shows the way in which the gas is backed up in the passage leading from the gas pump by the air from the charging pump. There is supposed to be, and no doubt there is, to a large extent a distinct line of demarcation between this pure air and the gas in its own passage; and this advanced charge of air which enters the cylinder as soon as the inlet valve is opened does the scavenging, and it is only when the air and gas begin to come in together that they form the mixture. Körting, in his original specification, laid considerable stress upon the special form

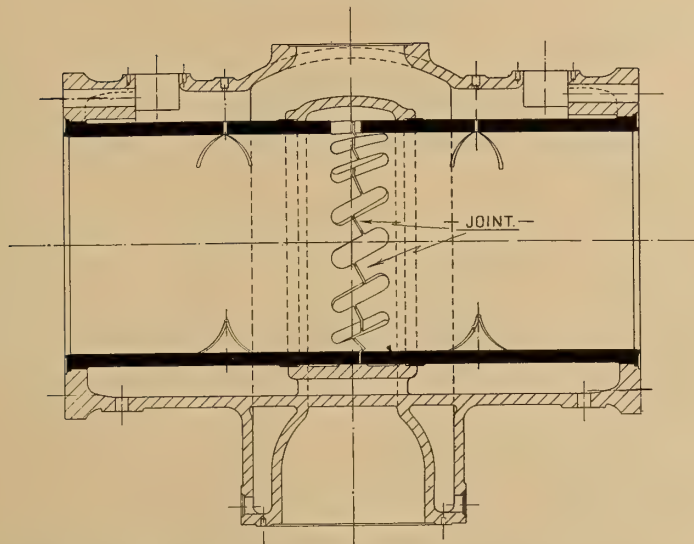


FIG. 5.—DETAILS OF CYLINDER FOR TWO-CYCLE ENGINE. GUTEHOFFNUNGSHUTTE, STERKRADE

of curved cylinder head as aiding to spread across the entire cross section of the cylinder the first layer of scavenging air, so that it was pushed forward by the charge of mixture as a solid wad of clean, cool air; and substantially the same section of head has been retained by all the builders of the Körting engine. In the recent Körting engine built by the De la Vergne Company, the amount of gas supplied at each stroke is regulated by means of a trip gear actuated by an eccentric on the lay-shaft, which opens a by-pass valve on the gas pump at the commencement of the discharge stroke about the point *A*, Fig. 3. The point of opening remains constant at all loads; but the valve is tripped and shut sooner or later, according to the position of the governor, and if it shuts before or on the point *B* the engine is working on full load. On light loads the by-pass is not closed so soon—say until about the point *C* on the dia-

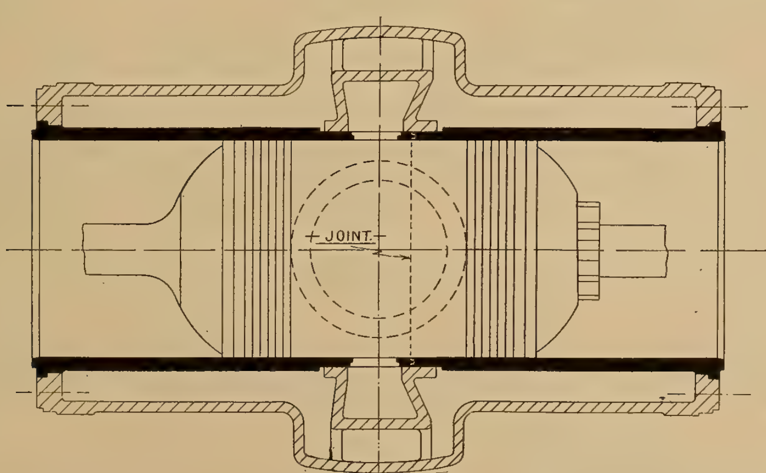


FIG. 6.—DESIGN OF CYLINDER BY KLEIN BROS., DALBRUCH. SHOWING ARRANGEMENT OF CENTRAL JOINT

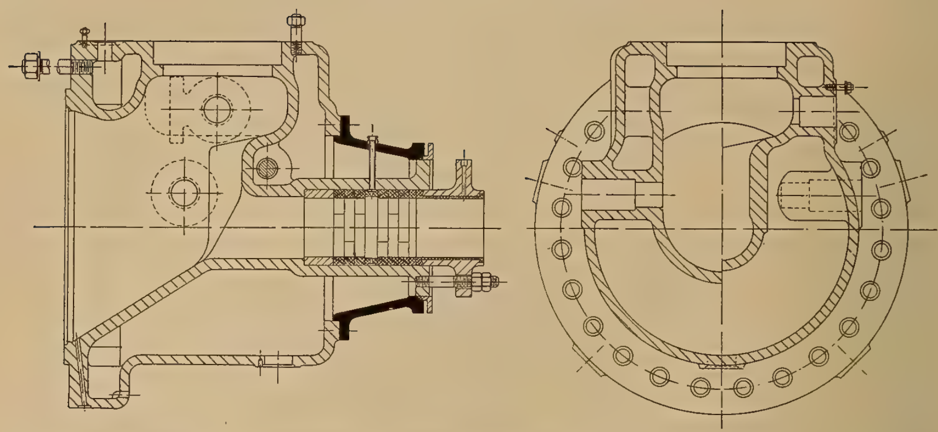


FIG. 7.—ARRANGEMENT OF KOERTING CYLINDER HEAD AS CONSTRUCTED BY THE GUTEHOFFNUNGSHUTTE

gram—and the amount of gas sent forward to the working cylinder is consequently less. Fig. 4 shows another view of the trip gear. As will be seen later on, in the two-cycle engines built by Messrs. Mather & Platt, a somewhat different arrangement of gas and air pumps is employed. It is obvious that, with a regulation of this kind at light loads, the gas will be backed up the passage a good way, while at overloads the thickness of the scavenging charge will be considerably diminished, and there may be a tendency for the mixture itself to escape down the exhaust ports. This is a point which has engaged the attention of all makers of this type of engine; but the difficulty may be considered as being, so far, practically overcome, as there are hundreds of Körting type engines at work with no more trace of unburnt gases in the exhaust than with a four-cycle engine. The absence of exhaust valves in the Körting engine renders it unnecessary to get underneath the cylinder, and, as a consequence, no pit or excavation is needed, and the framing may be made of two simple box castings with a cylinder bolted down straight thereon. In the original Körting engines the inner lining of the cylinders was cast solid with the outer jacket; but in more recent practice the inner lining is put in separately, and after being turned and fitted is parted through the centre of its length, the two portions being held in position by the end covers, and the joint being made at the middle by the exhaust belt. A certain amount of expansion takes place when at work, but apparently there is no difficulty in keeping the joint watertight. Fig. 5 shows a two-cycle cylinder made by the Gutehoffnungshütte Company, and Fig. 6 a slightly different design used on the two-cycle engines built by Messrs. Gebrüder Klein, of Dalbruch. In Fig. 5 the inner lining is parted through the centre line of the exhaust ports, in Fig. 6 the division is made a little on one side, and in both cases the same effect is obtained; that is to say, the inner tube has only to resist the bursting pressure due to combustion, and does not transmit any fore-and-aft stresses. A certain amount of trouble was experienced at first in connection with the design of the cylinder head when the water jackets were cast solid with the inner casing, but now a stuffing-box is provided at the outer end of the water jacket, which simply becomes a sort of tank to keep the interior of the head and stuffing-box cool. Fig. 7 shows the arrangement used by the Gutehoffnungshütte Company and Fig. 8 a design employed by the De la Vergne Company.

It is somewhat a question whether it is necessary to provide two tailrods to carry the long pistons of the Körting engines. Many of the Continental makers use these, and although at one time the writer thought tailrods were very desirable, this opinion has been modified by some years' practical experience with two 700 horse-power Körting engines; and the English makers of the Körting engine, Messrs. Mather & Platt, some time ago decided they were unnecessary. If tailrods are not used, it is desirable to have a large white metal shoe on the under side of the piston, which can be renewed from time to time as wear takes place.

Different makers use various constructions of pistons: the original Körting design is shown in Fig. 9, and an arrangement used by the writer is shown in Fig. 10. In the latter case the ends of the piston are composed of two forged steel cheeses, with a cast-iron intermediate shell held tightly between these. Two or three sizes of these cast-iron shells can be kept in stock to compensate for any wear of the cylinders when this becomes too much for the piston rings to take up, and if the liner or the inner tube of the cylinder is made renewable, the wearing parts of the cylinder and piston can be replaced an indefinite number of times. There is no more difficulty with stuffing-boxes on a two-cycle engine than with a four-cycle type, and piston rods of nickel steel with about 4 per cent. nickel give very good running results. The cooling water connections to the piston and piston rod are much the same on a Körting engine as they are on a four-cycle type. In Great Britain the ironmaster has accepted the idea of a gas blowing engine with great caution; but in Westphalia, Luxemburg and Belgium numerous groups of furnaces can be found which depend solely on gas engines for the supply of blast; and if the gas is used directly in an internal-combustion engine instead of indirectly under boilers to make steam to drive the blowing engine, a very considerable amount of gas is left free to be utilized in other ways. It is true that an engine for this purpose must be absolutely reliable, and must be capable of supplying the maximum amount of air required by the furnaces for twenty-four hours a day of 365 days to the year. The furnace itself under different conditions of working may require variable amounts of air; but whatever is wanted the engine must be ready to supply it, and the fact that gas-driven

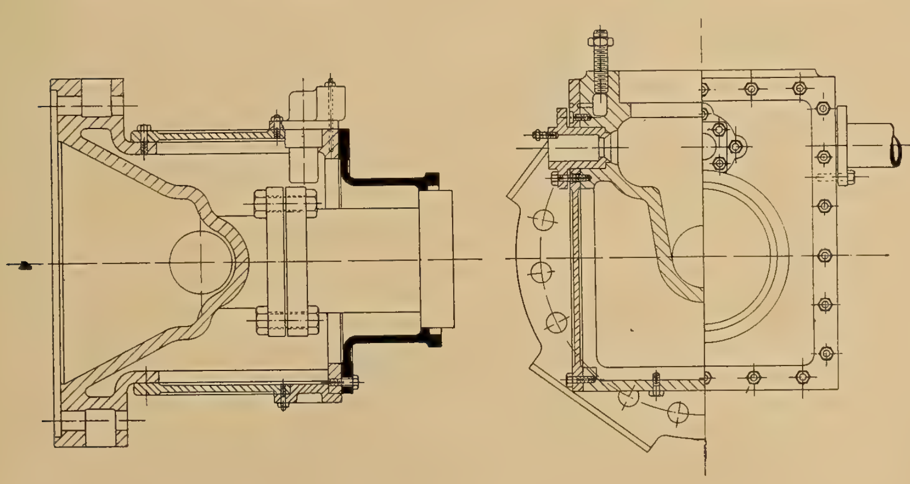


FIG. 8.—DETAILS OF KOERTING CYLINDER HEAD, AS BUILT BY THE DE LA VERGNE MACHINE CO., NEW YORK

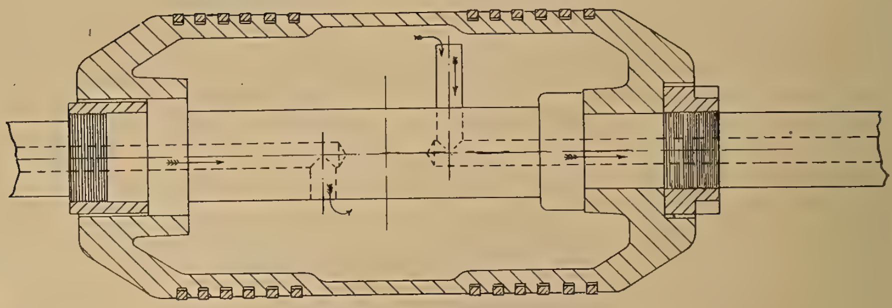


FIG. 9.—DETAILS OF KOERTING PISTON

blowing engines are coming so largely into use on the Continent and in the United States may be taken as a strong testimonial to the feeling of security with which ironmasters have come to regard this system of providing the necessary blast. The majority of gas-driven blowing engines run at far higher speeds than the old types driven by steam engines, but various improvements in actuating the valves on the blowing tubs have rendered it quite feasible to place the blowing cylinder directly at the rear of the engine and couple on direct to the tailrod. The facility with which the speed of a two-cycle engine can be regulated has led to them being extensively employed for blowing purposes, although the writer does not actually know the comparative number of two-cycle and four-cycle engines in use for this purpose. A good example of a gas-driven blowing engine station is illustrated in Fig. 11, which shows a group of four two-cycle engines coupled to blowing cylinders at the works of Messrs. Petits Fils de Fois de Wendel, Hayingen, Lorraine. These are single-cylinder engines driven by blast-furnace gas, the working cylinder being 30½ inches diameter, with the blowing cylinders 73 inches diameter, the stroke being in both cases the same, namely, 51¼ inches. At 70 revolutions per minute the blowing cylinders can deliver 18,000 cubic feet of air. The blowing engine to be seen at the rear end of the engine house is driven by an electric motor, which was installed as a temporary measure while preparations were being made to erect the gas engines. These engines were built by Messrs. Klein Bros., of Dalbruch, and the installation is only one out of a number of similar plants they have supplied in recent years. Four gas blowing engines by the same makers have been lately put down at the Froddingham Steel Works in Lincolnshire; in this case each working cylinder develops 1,000 horse-power.

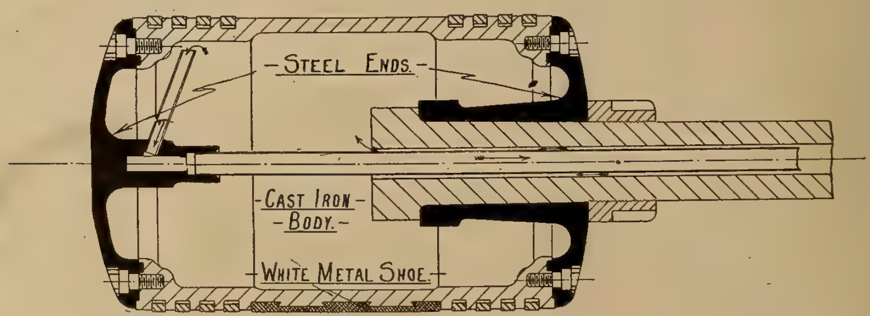


FIG. 10.—DESIGN FOR BUILT-UP PISTON, BY PERCY R. ALLEN

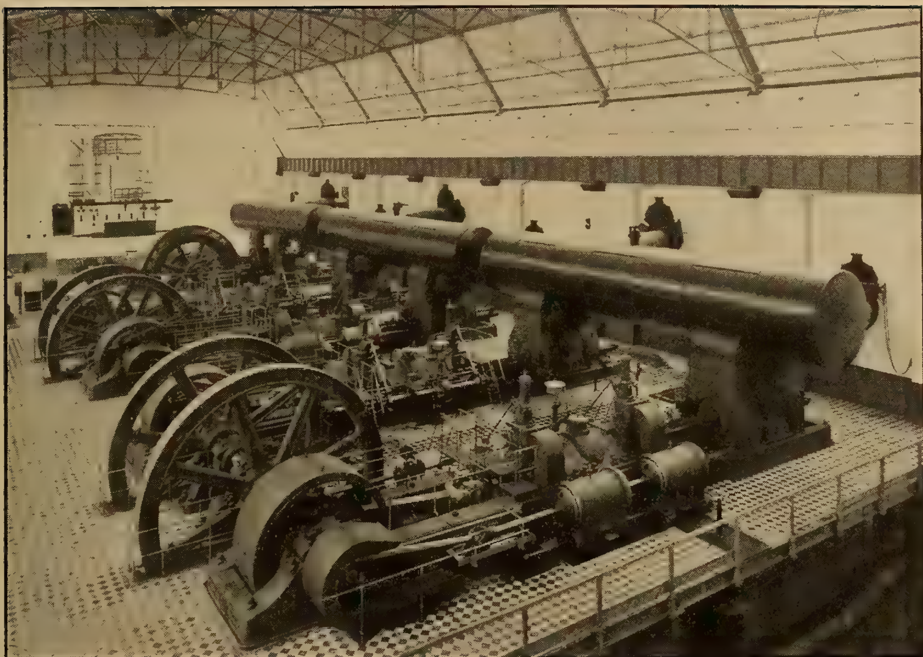


FIG. 11.—GAS-POWER PLANT AT THE WORKS OF PETIT FILS DE FOIS DE WENDEL, HAYINGEN, LORRAINE. FOUR BLOWING ENGINES USING BLAST-FURNACE GAS. KLEIN BROS., DALBRUCH

Another example of a two-cycle gas engine driving blowing cylinders direct is shown in Fig. 12, which represents one of the numerous engine houses at the Gutehoffnungshütte Works, at Oberhousen, where, altogether, 30,000 horse-power in the form of large gas engines is in daily use.

The Gutehoffnungshütte Company were one of the pioneer firms to use gas engines driven from their blast furnaces, and not only are they large users themselves, but at their Sterkrade works they build both four-cycle and two-cycle gas engines. The illustration shown in Fig. 13 shows a two-cycle engine built by the Siegener Machine Company, in which the tailrod drives the blowing cylinder and a dynamo is coupled to the crankshaft. The writer believes that this is the engine installed at the works of the Uckingen works of Gebrüder Stumm; at all events, they have one like it; and similar arrangements are used on the Körting type engines at the Park Gate Steel Works, near Sheffield; but, on the whole, it is dubious whether a combination of this sort is advisable except under special circumstances.

The double-acting stroke operation of the two-cycle engine naturally gives facilities for obtaining high powers in a single cylinder, and in Germany the Siegener Machine Company have already built a blowing engine in which 2,000 horse-power is developed in a single cylinder; and through the courtesy of the makers the writer is enabled to show an illustration of this in Fig. 14. This was supplied to Messrs. Stumm Bros. for their Neunkirchen works, and is one of the seven engines ordered by the same firm. The dimensions of the working cylinder are 43 5-16 inches by 55⅛ inches stroke, and the dimensions of the blowing cylinder 100 13-32 inches by the same stroke, viz., 55⅛ inches. The fly-wheel is 22 feet 11⅜ inches diameter, and weighs 38 tons, but this is not shown

in the illustration. The speed can be varied from 30 to 85 revolutions per minute, according to the requirements of the blast, and the normal pressure is 0.6 of an atmosphere, which can be raised to 1.02. The volume of the suction is 35,315 cubic feet normally per minute. The makers state that the charging work of the pumps has been ascertained to be only 5.5 per cent. of the horse-power, which is, of course, only a comparatively small proportion.

Now that it has been demonstrated that 2,000 horse-power can be satisfactorily obtained in a single cylinder, there would not seem to be any difficulty about using cylinders of the same dimensions either in a twin engine, a tandem engine or in a twin-tandem engine, and in the latter case a combination of four cylinders would develop 8,000 horse-power, and Fig. 16 shows a plan proposed by Messrs. Mather & Platt for a twin-tandem engine of this kind. In this case the charging pumps are arranged to be placed on the inner side of the bed-plates, and, as the main cranks are at right angles, the pumps can be driven direct from the cross-heads, each set of pumps feeding across the opposite set of cylinders.

Although the majority of large gas engines on the Continent and in America have hitherto been driven by waste gases from blast furnaces producing pig-iron, or from coke ovens with recovery plant, these are not the only waste gases that can be utilized. At the well-known copper works of the Mansfieldsche Kuperschlieferbauende Gewerkschaft, Eisleben, the firm of Gebrüder Klein, of Dalbruch, have put down a twin double-acting, two-cycle engine coupled direct to a three-phase generator. Through the courtesy of Mr. H. Spannagel, their British representative, the writer is enabled to reproduce an illustration of the rear view of this engine, Fig. 15. The particular interest in this installation lies in the fact that the waste gases from the copper furnaces have a low calorific value and contain a large proportion of carbonic acid. This makes them difficult to ignite, and to overcome this an auxiliary supply of producer gas obtained from waste coke and lignite in a Pintsch producer is added to the gases from the copper furnaces. This brings the average calorific value of the gas up to about 700 calories; and although with this mixture the ignition has to

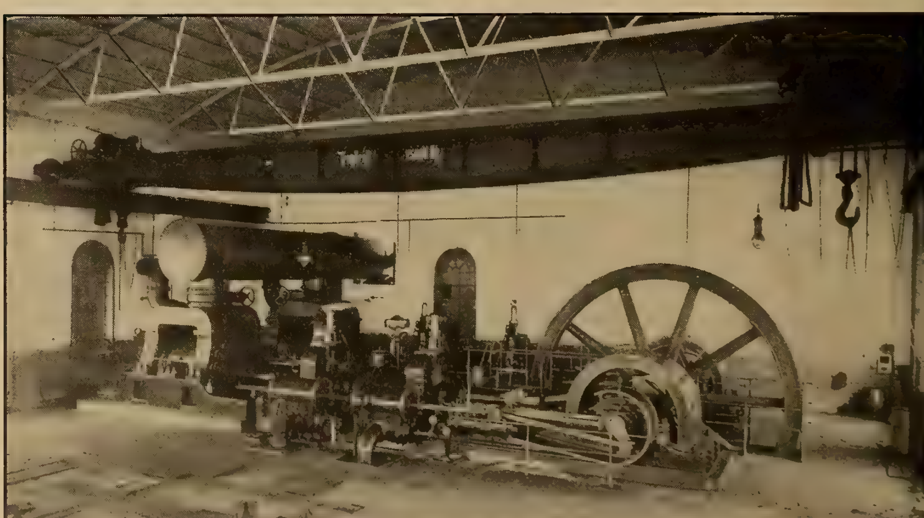


FIG. 12.—TWO-CYCLE BLOWING ENGINE AT OBERHAUSEN. GUTEHOFFNUNGSHUTTE, STERKRADE

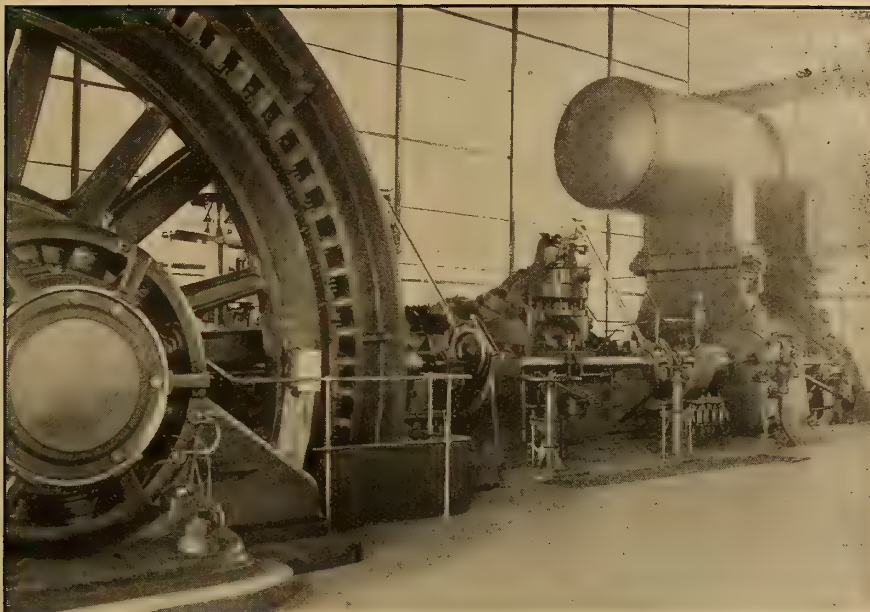


FIG. 13.—TWO-CYCLE GAS ENGINE AT UCKINGEN. THE SAME CYLINDER DRIVES BOTH DYNAMO AND BLOWING CYLINDER. SIEGENER MASCHINENBAU A. G.

be advanced 35 degrees before the dead centre, a very good working diagram is obtained. The pressure reached during the compression period is 227 pounds to the square inch, rising at the moment of explosion to 360 pounds or thereabouts. The diameter of the cylinders are 32¼ inches, with a 51 3-16 inch stroke. Under ordinary circumstances the mean effective pressure in the cylinders is 56 to 64 pounds, while if the gas is enriched up to 900 calories a mean effective pressure of 79 to 92 pounds is reached. The gas from the copper furnaces has not only to be

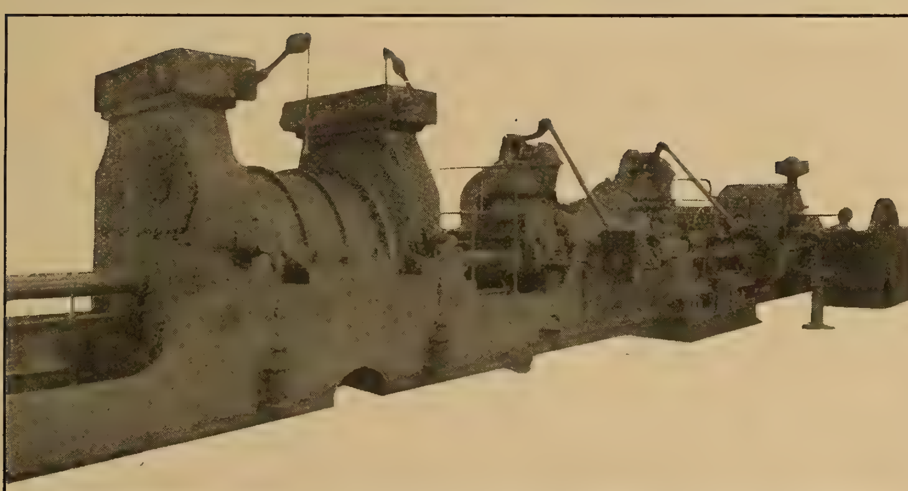


FIG. 14.—GAS-DRIVEN BLOWING ENGINE AT THE STUMM WORKS AT NEUNKIRCHEN, 2,000 HORSE-POWER. BUILT BY THE SIEGENER MASCHINENBAU A. G.

cleaned but has to be purified before reaching the engine. A Thiessen washer is used for the cleaning, and a scrubber with iron turnings used for the purification.

The more extensive use of low-grade gases produced in certain metalliferous operations may become a thing of some importance in the future. Already experiments have been carried on in connection with gases given off during the manufacture of carbide of calcium, and the internal-combustion engine with a high compression offers facilities for profitably utilizing a quantity of gas which would have little value if used as fuel under a boiler.

It is often used as an argument against the large gas engine that it has little capacity for carrying overloads, although as a matter of fact the writer has frequently run Körting engines from 20 to 25 per cent. above their rated capacity for quite lengthy periods. However, admitting this statement to be true in a general way, the use of gas engines may, under certain circumstances, render a power station capable of dealing with occasional demands for overload in a very satisfactory manner; for instance, at the municipal pumping station at Wilmersdorf, near Berlin, four Körting engines are installed, coupled direct to Borsig pumps arranged on the same bedplate. In the ordinary course of events two of these engines are amply sufficient to deal with the average daily flow of fluid, and these engines are fed from suction producers. These may be taken as units designed to deal with the normal daily output; but as occasionally the district is subject to sudden floods, which have to be dealt with promptly, city gas is laid on, and by the mere change of a valve the two spare engines can be put into commission with illuminating gas and the whole station placed on full load in three minutes. Thus the capital expenditure on the producer plant is saved, space is economized, and there are no stand-by losses through keeping producers ready to put on that might

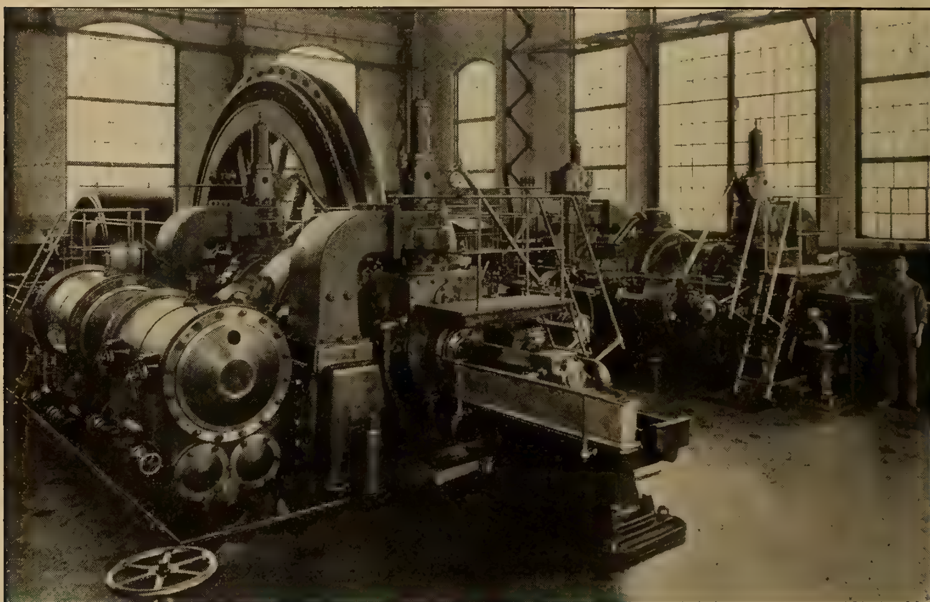


FIG. 15.—TWO-CYCLE GAS ENGINE AT THE MANSFIELD COPPER WORKS, EISLEBEN, OPERATING WITH WASTE GASES FROM COPPER FURNACES. KLEIN BROS., DALBRUCH

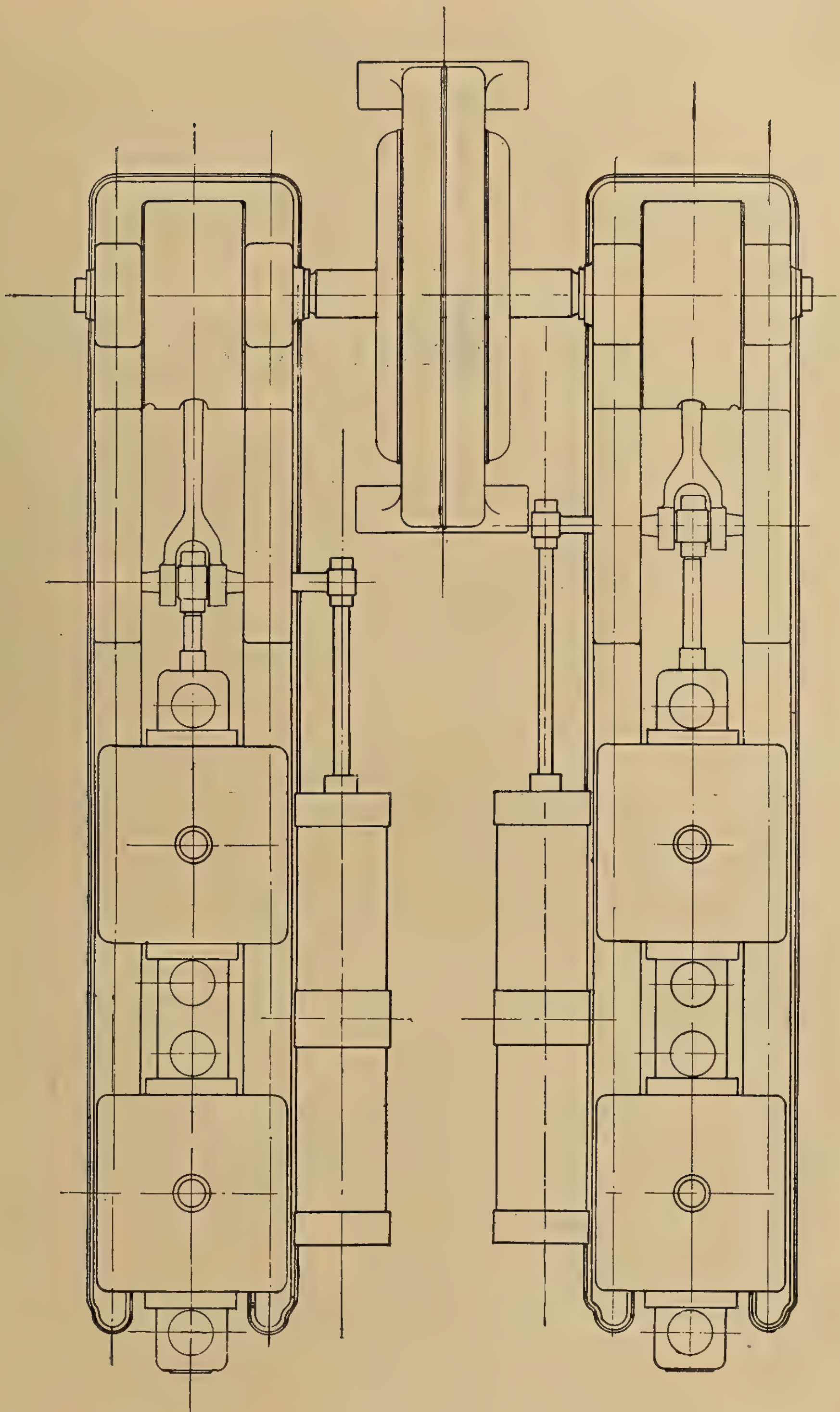


FIG. 16.—GENERAL ARRANGEMENT OF TWIN-TANDEM, TWO-CYCLE GAS ENGINE OF 8,000 HORSE-POWER, AS PROPOSED BY MESSRS. MATHER & PLATT

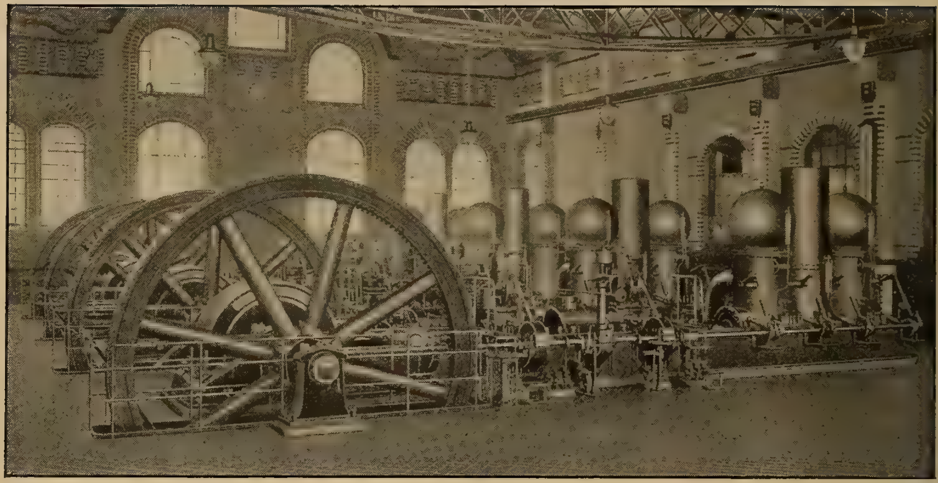


FIG. 17.—KOERTING GAS ENGINES DRIVING BORSIG PUMPS, AT WILMERSDORF WATERWORKS, NEAR BERLIN

only be required once or twice a year. Fig. 17 shows one unit of the plant. The engines are 300 horse-power each, and when run at 85 revolutions per minute the double-acting Borsig pumps deliver 3,800 gallons per minute to a height of 220 feet. The producer gas has a normal value of 140 B. T. U. per cubic foot, and the town's gas about 600. As this will be seen from Fig. 17, the valves of the pumps are automatically moved, being fitted with modifications of the Riedler gear. The engines were built by Messrs. Körting themselves at their Hannover works, and the same

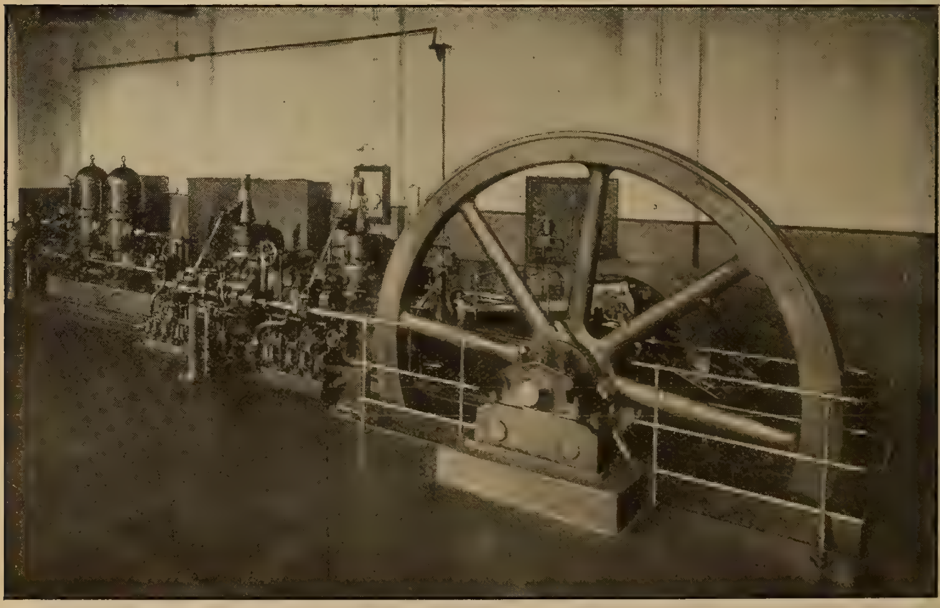


FIG. 18.—GAS ENGINE DRIVING HIGH-PRESSURE HYDRAULIC MACHINERY AT HOERDE, SIEGENER MASCHINENBAU A. G.

firm have supplied a large number of gas engines, both two and four-cycle, to waterworks on the Continent.

Gas engines have, of course, been used extensively in England for driving pumps; but not to any large extent for producing high pressures, at all events direct coupled. However, they can be used for this purpose, and the illustration shown in Fig. 18 is, perhaps, due to the fact that producer-gas installations for power purposes have been more developed in England.

From one point of view, driving a cotton mill is about as exacting a kind of work a gas engine can be called upon to perform. Whether driving mules or ring frames, exceedingly steady turning is essential,

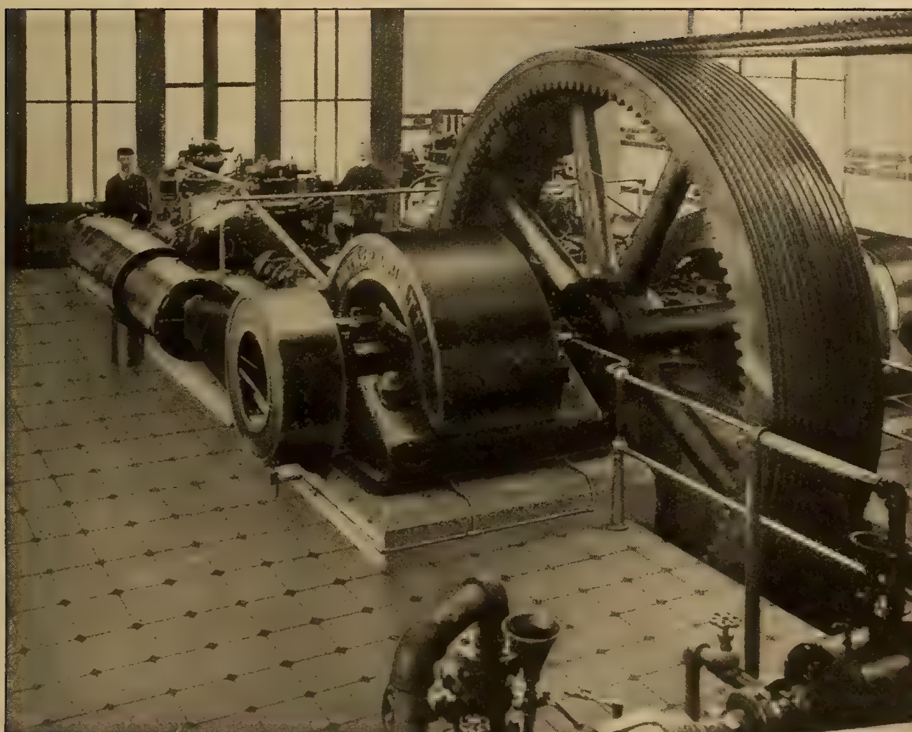


FIG. 19.—TWO-CYCLE GAS ENGINE AT THE STALEY MILL. MESSRS. MATHER & PLATT, LTD., MANCHESTER

shows an accumulator pump with a single-cylinder, double-acting Siegener two-cycle gas engine. This is installed at the Hörder Bergwerks and Hütten Verein, and has a pumping capacity of 98 cubic feet per minute against a pressure of 370 pounds to the square inch. Although the Continental makers can justly claim precedence in the application of large gas engines to utilize blast-furnace and coke-oven gases, yet in the important field of mill driving they have so far attempted very little; and this and not only must the engine be capable of close governing, but the cyclic variation itself must be small; there must be a practical absence of misfires or pre-ignitions, and the engine must always be capable of being started up, probably with full load on, with absolute certainty; in other words, it must be as perfectly reliable as the best type of steam engine.

A few years ago it would have been flatly denied that any large gas engine could ever fulfill these condi-

tions; but the vertical Westinghouse engine at Hollins Mill, and the horizontal two-cycle engine built by Messrs. Mather & Platt for Staley Mill, have both done admirable service since they were put to work. The Staley Mill engine is shown in Fig. 19. It will be seen that it is a twin engine with a grooved fly-wheel for rope driving between the two sides, and presents a somewhat unusual appearance to anyone accustomed to the levers coupled to the eccentric rod proper, as will be seen from the illustration. The duplicate igniters are worked directly off the valve gear, an arrangement which gives considerable facilities for exact timing of the spark. No tailrods are used, but the cross-head is of generous proportions and runs in external guides, which form an oil bath. Fig. 20 shows the arrangement of charging pump for the air and gas. These are placed

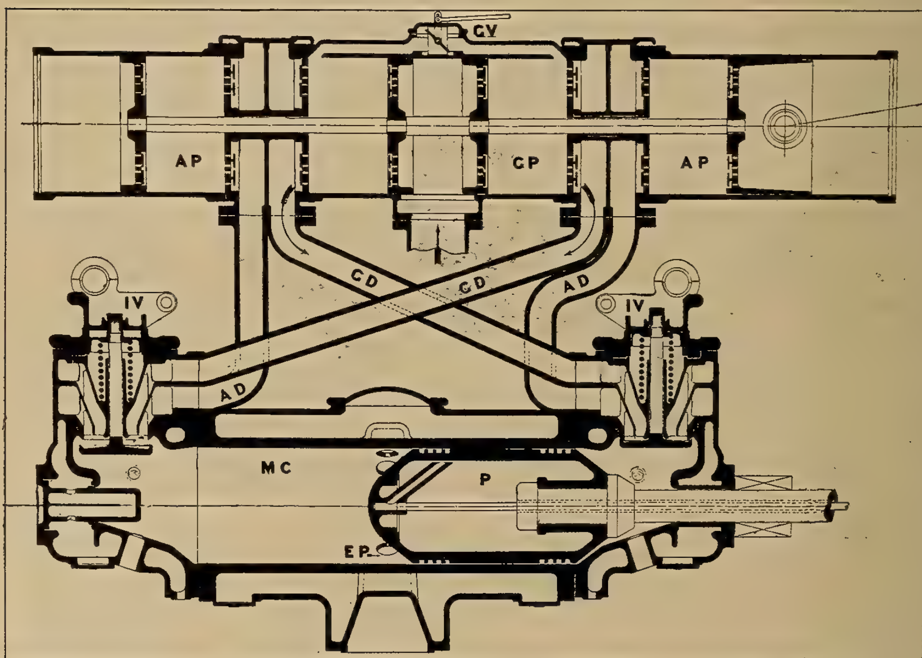


FIG. 20.—ARRANGEMENT OF CHARGING PUMP OF THE STALEY MILL ENGINE. MATHER & PLATT, LTD.

ordinary Körting design. However, the modifications introduced by Mr. Alan Chorlton, who has been responsible for this design, have been entirely in the direction of simplification and dispensing with all redundant parts.

In the first place, it will be seen that the valve gear operating the inlet valve has been reduced to one eccentric for each cylinder, and these eccentrics are mounted on the crankshaft direct, thus dispensing with the lay-shaft. The necessary movement is imparted to the valve by rolling

by the side of the frames parallel to the power cylinder. The double-acting pump for the gas is placed between the two single-acting pumps for the air. The three pumps are thus in line and secured to one another, as well as to the engine frame. The pump cylinders are separated from each other by intermediate delivery-valve boxes, each of which is divided by a diaphragm into passages for the gas and air, respectively, and these contain automatic valves. The hollow gas piston is fitted on both faces with automatic valves,

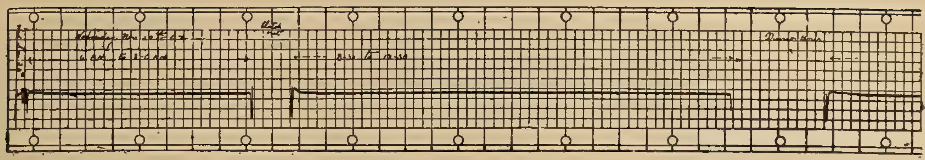


FIG. 21.—MOSCROP DIAGRAM OF ENGINE AT STALEY MILLS

and is also provided with slots in its periphery. Suction ports are made in the walls of the gas-pump cylinder, which, when uncovered by the hollow piston, place the gas supply main in communication with one or the other end of the pump. When, however, the ports are masked by the piston, the gas can enter its interior through the slots and then pass through the automatic valves into the pump cylinder on each suction stroke. With the object of delaying the charging of the gas until after the scavenging by air has been effected, which is necessary in internal-combustion engines of the two-cycle type, the piston, at a predetermined position of its stroke, which is fixed according to the calorific value of the gas in use, overruns the ports, thus cutting off the gas supply, and by its further movement forces the gas through the automatic valves into one or other of the valve boxes and thence to the gas passage described later on. The front single-acting air pump is provided with an extension, which serves as a slide for the cross-head and connecting-rod which operates the pumps from the subsidiary crank on the main crankshaft of the engine. The hollow gas piston, as well as the pistons in the air pump, which latter are also provided with automatic valves, are all mounted on one pump rod. Referring to Fig. 20, it will be seen that the forward end of the gas-pump cylinder and the back air-pump cylinder must each communicate with one of the main inlet valves to the power cylinder, and, similarly, the back end of the gas-pump cylinder and the forward air-pump cylinder must communicate with the other main valve. This is accomplished by means of a very compact arrangement of passages in the engine frame. A chart taken by a Moscrop recorder is shown in Fig. 21, and is a good example of exceedingly steady turning. Diagrams 21*a*, 21*b*, 21*c* show cards taken from the air pumps, gas pumps and main working cylinders, respectively. The peculiar shape of the toe of the diagram shown in Fig. 21*c* is found in nearly all the gas engines in which the exhaust ports are uncovered by the passage of the piston. The best length of ports, and consequent duration of the exhaust, is a matter that the various makers have more or less determined by experiment. Messrs. Pokorney & Wittekind, of Frankfurt, in their modification of the Körting engine, slope off the exhaust ports and caused a more gradual opening and closing.

a.—Air Pump...R. P. M. 115, I. H. P. 9.81, Area 0.54, Length 2.45, M. E. P. 3.52

b.—Gas Pump. R. P. M. 115, I. H. P. 7.94, Area 0.78, Length 2.74, M. E. P. 2.84

c.—Working Cylinder. R. P. M. 115, I. H. P. 196, Area 0.95, Length 2.51, M. E. P. 75.8

FIGS. 21, *a*, *b*, *c*.—DIAGRAMS FROM STALEY MILL ENGINE

They also propose to use only one charging pump and to make the air draw the gas in by a kind of injector action, the annular gas valve being only opened after the scavenging air had flown in. However, the writer is not aware how far experiments have been continued in this direction.

Coming now to the Oechelhaeuser engine, the idea was the original subject of a patent taken out by Oechelhauser and Junkers in the year 1892, and as the arrangement was proved to be successful by the behaviour of a 600 horse-power engine put down at the Hoerde Steel Works near Dortmund, a company of the Kraft-Gas Gesellschaft, of Berlin, was formed to exploit the new type; and as orders of considerable magnitude were received, arrangements were made with two influential firms—Messrs. Borsig, of Berlin, and the Ascherleben Company—to construct these engines, and quite a number of these are now at work.

The principle of the engine is, to a certain extent, similar to that of the Körting engine, inasmuch as the exhaust gases are released from the cylinder by the passage of the piston itself over an annular ring of ports, the exhaust gases being further swept out by a scavenging charge of air, which is followed by a charge of mixture, this charge being subsequently compressed and fired at the end of the return stroke; but only one working stroke is obtained during one revolution of the crankshaft, as against two in a double-acting Körting engine, and the charging arrangements are somewhat different. The working cylinder in the Oechelhauser engine is practically a long, open tube, suitably jacketed and fixed down to a bedplate bolted to the frame carrying the crankshaft bearings. In this tube there are two trunk pistons, which are connected to a three-throw crank. The piston rod of the front trunk is coupled by a connecting-rod to the middle crank throw, while the piston rod of the back trunk is coupled to the outer throws by means of a back crosshead and two side rods. The general arrangements of the various parts can be seen from the illustrations 23, 25 and 26, which represent one of the latest types of Oechelhaeuser engine. As the crankshaft revolves the pistons move in opposite directions, alternately approaching each other toward the middle of the cylinder and then receding to the outer ends. Now if a charge of mixture is imprisoned between the two pistons, as they approach one another it will evidently be compressed to a final volume, depending upon the clearance between the two pistons at the end of each stroke when the cranks are on the dead centre; then if the charge is fired the pistons will be driven away from one another to the ends of the cylinder, the pressure falling at the same time during the progress of this stroke. There are neither inlet nor exhaust valves in the working cylinder proper, the only movable valve being the starting valve for admitting the compressed air; but at the front end of the cylinder there is a ring of exhaust ports, which is uncovered as the front trunk nears the end of the outward stroke, and at the rear end of the cylinder there are two rings of ports, the ring furthest from the back end of the cylinder communicating with an air receiver, while the adjoining ring nearest to the end is connected to a gas receiver. Air and gas under a certain pressure are fed into these receivers by means of a pump worked directly by a tailrod on the back crosshead or indirectly by means of a rocking lever and links. In the engines built by the Aschersleben Company the charging pump is driven by means of a subsidiary crank on the main crankshaft. Where these engines are worked off blast-furnace or poor producer gas the volumes of air and gas to be supplied do not differ very much, and one double-acting pump may be used, one end supplying the air and the other supply-

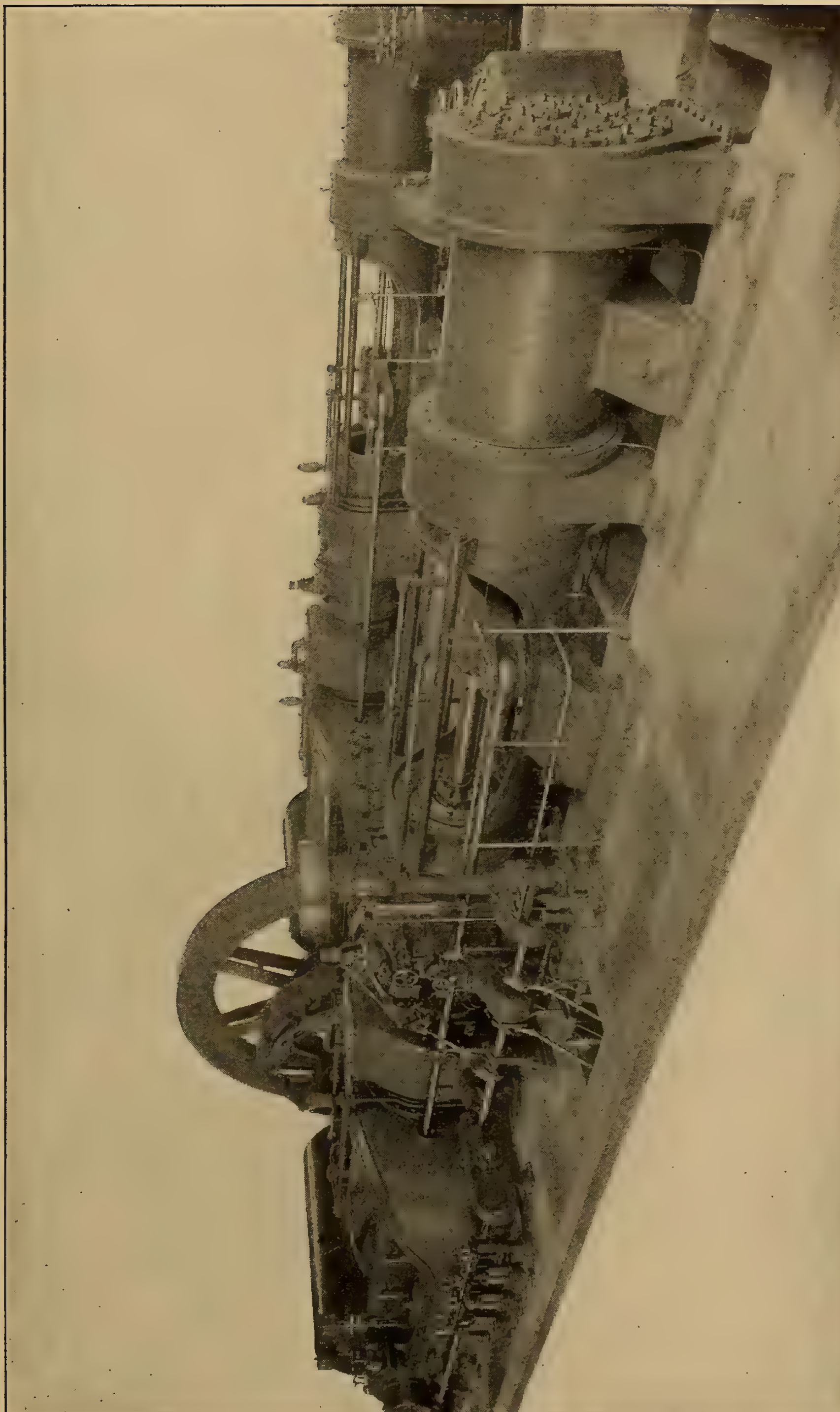


FIG. 22.—TWIN OECHELHAEUSER GAS BLOWING ENGINES, BUILT BY A. BORSIG, TEGEL, BERLIN, FOR THE KRUPP RHEINPREUSSEN WORKS

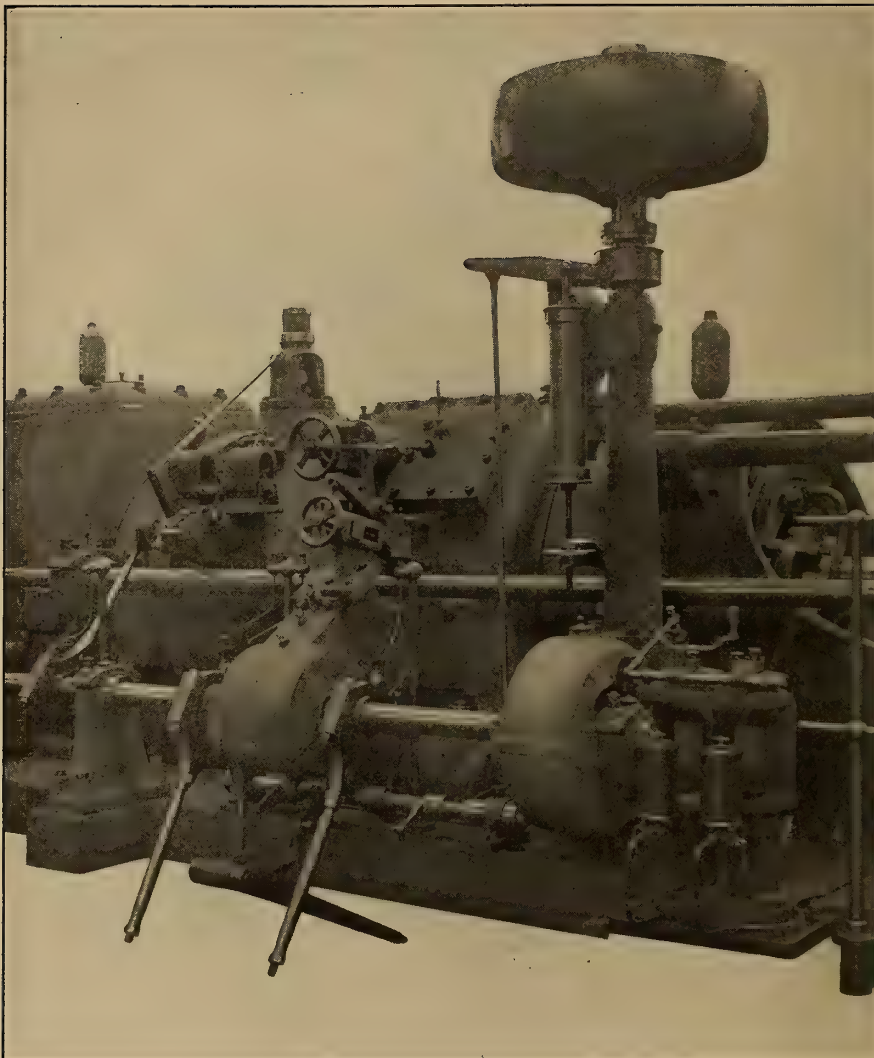
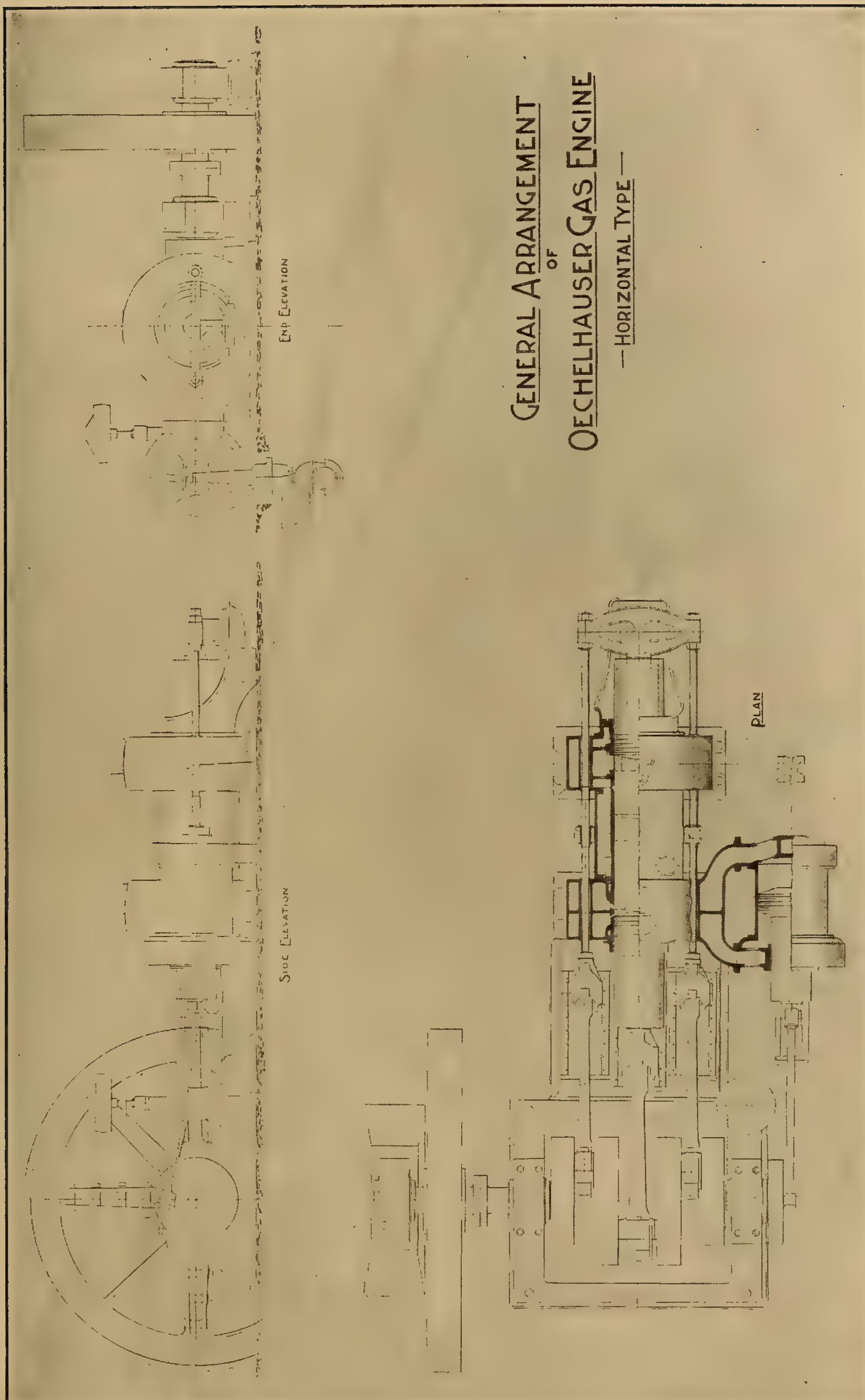


FIG. 23.—VALVE GEAR OF THE OECHELHAEUSER GAS ENGINE. A. BORSIG, TEGEL, BERLIN

ing the gas; but where the volumes of the constituents of the mixture are widely different, as with coke-oven gas, it is found more convenient to use separate pumps. However, whether one or two pumps are used, the distribution arrangements are substantially the same. As the front piston approaches the end of the stroke the long exhaust ports at that end are uncovered and the products of combustion begin to escape to the atmosphere, then the back piston uncovers the ring of the air ports and the scavenging charge of air begins to flow in, helping to drive the burnt gases out through the exhaust ports at the other end. The further movement of the back piston then uncovers the gas ports and gas enters, due to the pressure in the receiver, and begins to form mixture with the still incoming air. This formation of mixture continues until the gas ports are covered by the return of the piston, and as the piston continues



FIGS. 24, 25, 26,—ARRANGEMENT OF OECHELHAEUSER TWO-CYCLE GAS ENGINE, AS BUILT BY MESSRS. WILLIAM BEARDMORE & CO., LTD., GLASGOW

to move towards the middle of the cylinder the air ports close, and when the front piston has shut the exhaust ports there remains in the cylinder a long plug of air and gas, which represents the mixture formed while both air and gas ports were opened. This more or less homogeneous plug of mixture is capped at each end by a plug of air, which represents the amount of air that entered at the air ports before the gas ports opened and after they were closed; but how far this stratification continues during the compression stroke it is difficult to say, and considerable discussion has taken place about the question.

Several arrangements of regulation have been employed on the Oechelhaeuser engine, mostly depending upon the devices for varying the pressures in the air and gas receivers by controlling by-pass valves on the air and gas pumps, according to the position of the governor. The effective regulation of this type of engine depends a good deal upon the distance between the pumps, the receivers and the working cylinder, and in the later engines these have been put as close together as possible to avoid undulatory fluctuations in the gas and air pipes. These inertia effects are often overlooked in considering the charging phenomena of gas engines, and may have a very disturbing effect upon the mixture entering the cylinder.

A large twin Oechelhaeuser engine built by Messrs. Borsig for one of the Krupp establishments is shown in Fig. 22, and Fig. 23 gives a more detailed view of the governing gear and the rear or ignition end of the cylinder; the small valve seen at the top is connected to the compressed air starting system, and is worked by the same gear that actuates the igniters. In some cases movable annular rings round the air and gas ports are provided, so as to further adjust the incoming proportions of gas and air; but it will be impossible to describe in detail here all the arrangements that have been proposed.

Oechelhaeuser engines having a single cylinder and giving 1,500 to 1,800 horse-power have actually been constructed, and it has been proposed to construct them in twin form up to 5,000 horse-power. It is claimed for this type of engine that the cylinder may be kept of comparatively small diameter, and that, owing to both pistons moving at the same time, the expansion takes place very rapidly, and, further, that the engine runs in very perfect balance, and that the efficiency is good, while the fuel consumption is low. In one of Prof. Meyer's experiments this was found to amount to 6,640 B. T. U. per I. H. P.-hour. All these claims may be admitted, and the writer has seen many large Oechelhaeuser engines on the Continent driving dynamos and blowers extremely well. On the other hand, this type of engine occupies a considerable floor space, was an expensive engine to construct, and, as a single-cylinder engine, has only one impulse per revolution, as against two in the Körting design; and it was for these reasons mainly that the makers found it difficult to compete with smaller engines of equal power which could be more economically constructed, and at one time it seemed as if these commercial considerations would cause this type of engine to be dropped. However, Messrs. William Beardmore, of Glasgow, secured the British rights; and while they found that the original German designs gave satisfactory results when installed in works under their own immediate control, the same arguments that were used against the engines on the Continent applied here; but instead of abandoning the principle of the engine Messrs. Beardmore's engineers, in conjunction with the scientific advisers of the parent concern, the Kraft Gas Company, of Berlin, set to work to remodel and simplify the engine generally, and the revised type thus evolved is shown in Figs. 24, 25 and 26. It will be seen that the whole engine is kept more compact

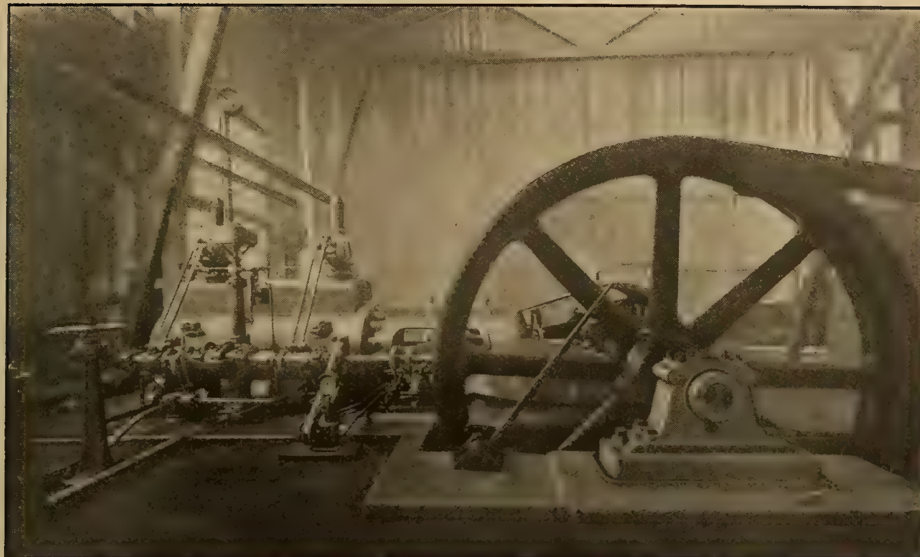
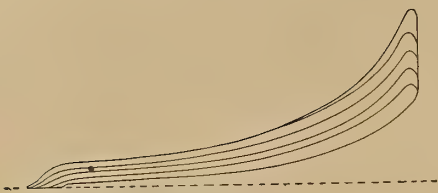


FIG. 27.—EXPERIMENTAL TWO-CYCLE ENGINE OF 250 HORSE-POWER AT THE BORSIG WORKS, TEGEL, BERLIN

than in the previous designs; only one charging pump is used both for the air and gas, and this is placed at the side of the engine and driven by a crank at the end of the shaft, as in the Körting arrangement. The governing arrangements have also been much simplified, and altogether in its new form it seems likely that this type of engine will stand a fair chance in competition with other designs; and it is somewhat gratifying to note that these alterations have been introduced by British makers. A patent has recently been taken out in Germany by Prof. Junkers for a special form of intermediate cooler, which is placed between the charging pumps and the working cylinder. The patent appears to be in the particular construction of the cooler itself. A marked improvement, both in the running of the engine and its capacity to give out more power, seems to have resulted where these coolers have been applied. On an Oechelhauser engine at Hoedre the cooler reduced the temperature of the entering charge from 90 degrees to 30 degrees C., and the output of the engines increased from 390 horse-power to 460, and experiments on a smaller Körting engine gave somewhat proportionate results. As far as can be gathered from the published reports, the total amount of cooling water used in the engine was not increased, as less was wasted in the cylinders; and, moreover, the use of the cooler was not found to put any more work upon the charging pumps. It is proposed to supply such coolers to the ordinary four-cycle engine, the idea in this case being that the suction will always take place under conditions of constant temperature. It is easy to see that, at all events on a two-cycle engine, an intermediate cooler of this kind would have considerable advantages, and it can be easily adapted to the ordinary type of Körting engine by placing the nest of tubes in the side frames. The Oechelhauser engine at Hoedre, on which this experiment was tried, is interesting from the fact that the air supply is not obtained from a pump on the engine, but the air receiver is supplied by a connection from a neighbouring blast-furnace blowing engine. This is a step in the direction of what has been advo-



a.—Diagrams from Borsig Engine with Petzel Regulation

Diagrams with Ordinary Tyo-Cycle Regulation

FIGS. 28, 28*a*.—DIAGRAMS FROM BORSIG EXPERIMENTAL ENGINE

cated by Prof. Diederichs and others; that is, that the pumping arrangements should be of the nature of fans or blower, keeping sufficient pressure in receivers and regulating the amount of the charge by throttling between the receiver and the cylinders. The writer is not aware that this has yet been worked out in a practical way, but an arrangement of this sort would certainly give facilities for a more positive supply of scavenging air, as an independent admission of this would render this independent of any questions of stratification or adequate backing up of the gas in the passages.

In the well-known Premier four-cycle engine the scavenging charge is introduced by an independent pump; and in a new type of two-cycle engine with which experiments are being carried on at the Borsig works in Berlin the scavenging charge is introduced by a separate valve independently of the inlet valve. An illustration of an experimental engine of this type of 250 horse-power is shown in Fig. 23. As this engine is still in the transition stage, it is not possible to say the exact nature of the charging arrangements which will be ultimately settled upon; but a comparison of the two diagrams, Figs. 28 and 28*a*, give a comparison between an ordinary two-cycle engine regulated in the usual manner, while 28*a* shows the regulation which is to be aimed at, and which is claimed to be obtained in this engine by Petzel's patent. It will be seen at full load there is not much difference in the diagrams, but it is as the load falls off that the superiority of this method of governing becomes marked. A very interesting description of this engine has been published by Messrs. Borsig, but as yet this is in German; and though the diagrams of the various stages of charging given therein are very interesting, they would be unintelligible here without a lengthy explanation. While the writer has had for many years control of the operation of a number of fairly large gas engines, both of the four-cycle and the two-cycle type, he is still loth to express a decided opinion for one or the other. In actual practice both types appear to give equally satisfactory performances, provided the difference in their method of operation is properly appreciated. The extra power required, due to the pump work, on a two-cycle engine is probably counterbalanced by the extra friction due to the second cylinder and all that appertains thereto that is required on a four-cylinder engine to give the same number of impulses; and, altogether, when everything comes to be reckoned up, the over-all efficiency of two engines of equal power by equally good designers will be found to be very much the same, whether they are two-cycle or four-cycle.

Whether the large gas engines can be safely relied upon to work continuously depends chiefly upon whether they are purchased from experienced manufacturers in the first instance and whether they are installed and supervised by intelligent and unprejudiced men afterwards. Personal experience has convinced the author that a large power plant can be worked with the same immunity from breakdowns as a steam

plant and at about one-half the operating costs. Numerous log sheets of actual runs are available which show that large gas engines can be run practically continuously; for instance, a Nurnberg four-cycle blowing engine at the Rochling'sche Eisen & Stahlwerke, Diedenhofen, Germany, ran for nineteen months and made 13,639½ hours out of a possible 13,670 hours, and most of the time it was out of action, due to repairs necessary to the blast furnace itself. The running costs for wages, stores and repairs came out at 2*s*. per working hour, or 0.0128*d*. per B. H. P.-hour—of course, without reckoning any charge for gas. This happened to be a four-cycle engine; but some of the large Körting type engines on the Continent show equally good records, and the writer can testify from actual experience that a three to four months' run, working continuously day and night, may be expected as a matter of course with a suitable type of large gas engine.

In the present articles it has only been possible to deal with the technical aspects of large gas engines in a very general way; but the writer trusts that the illustrations that have been given of large engines actually at work and the existing installations that have been referred to will go to prove that we have no need to wait any longer for the advent of the large gas engine, as it has already arrived.

WATER-POWER FROM STREAMS OF MODERATE FALL

By Sylvester Stewart

In view of the recent and present interest in the conservation of national resources it is especially desirable to consider the utilization of natural sources of energy, and thus diminish the drain upon the coal supply of the world. This is particularly the case with the demand for power in moderate and small quantities, since it is in just such cases that the greatest wastes in the development of steam power occur. By utilizing the power which may readily be generated from rivers and streams of moderate fall large economies in fuel may be effected, while the cost of transportation at the same time is almost eliminated. This obvious element in national economy appears in nearly every country, and its development may be expected as a natural sequence of the demand for a reduction in national wastes.—THE EDITOR.

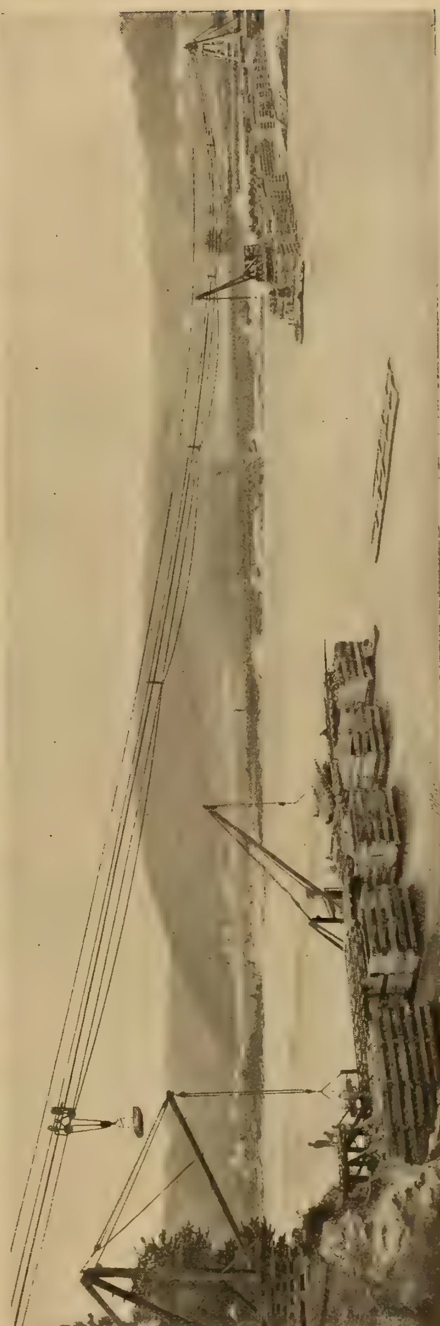
THE assertion that not one ten - thousandth part of the water-power of the world is utilized will sound like an exaggeration, but it is well within bounds. The greater part of this power, of course, is in out-of-the-way places, or exists in rivers so deep and sluggish that the energy obtainable from them would cost more than steam power, at the present price of coal. But we could take out, in regions where power is needed, at least a hundred times as much water-power as is now employed, furnishing a safer and cleaner power than steam, at a lower cost, and thus prolong the existence of our coal fields.

The erroneous assumption that high dams are necessary to obtain water-power throughout the entire year has prevented the utilization of the power of many rivers and restricted water-power plants almost entirely to natural water-falls.

A dam 50 feet high in a river of medium size will yield about seven times as much power as a dam 10 feet high. A column of water falling 10 feet yields one-fifth as much power as one falling 50 feet, but water does not fall the entire height of the dam. In a river of medium size we may assume the depth of the river on the lower side of the dam to be 3 feet, in low water. The water of a 10-foot dam would then fall 7 feet, and that of a 50-foot dam 47 feet, but the superstructure of the latter (all above the foundation) costs about thirty-five times as much, because it must be five times as high and about seven times as thick as the 10-foot dam. The foundation of the 50-foot dam sometimes costs much more than fifty times as much as that of the 10-foot one, for high dams must be built of masonry or concrete, and must therefore have very deep and solid foundations, while a low dam may be a timber crib filled with broken stone, gravel, etc., which requires scarcely any foundation.

Hydraulic motors may be divided into two classes, those which utilize the head of the falling water, such as turbines, and those which are operated by the action of the current of the nearly horizontal stream. Turbines show an efficiency as high as 80 per cent., while the efficiency of the current motor is only about half as great. The turbine, however, requires a considerable head of water, and in order to develop power

DAM ACROSS YADKIN RIVER, NORTH CAROLINA, FOR THE HYDRO-ELECTRIC DEVELOPMENT OF 30,000 HORSE-POWER. LIDGERWOOD CABLEWAY EMPLOYED IN CONSTRUCTION



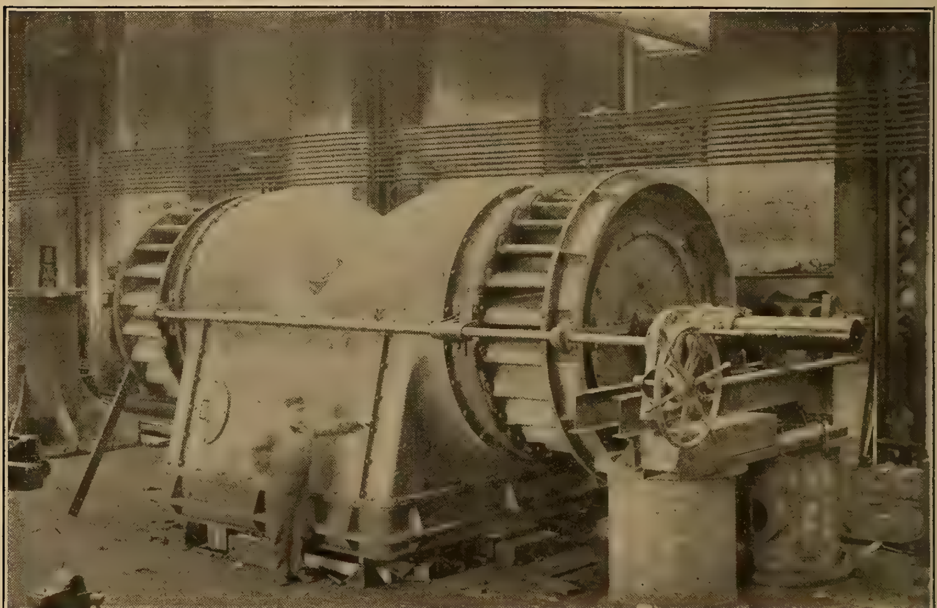
CONSTRUCTION OF M'CALL'S FERRY DAM ACROSS THE SUSQUEHANNA RIVER. LIDGERWOOD CABLEWAY BUILDING COFFERDAM

throughout the entire year it is necessary to build a dam rising well above the high-water line; otherwise, when the dam is drowned, the head of water disappears and the turbine ceases to work.

Now, if, instead of using turbines alone, a mixed system is employed, using a dam of moderate height and adding a battery of current motors, undershot wheels, or the like, a continuous supply of power might be developed throughout the year, for varying heights of water. Such a system would enable hundreds of rivers of moderate fall to be put to work and produce changes the benefit of which can now scarcely be estimated.

With such a combination, during periods of low water, the entire amount available would be passed through the turbines, utilizing the head and volume to its maximum efficiency. As the river begins to rise, the effective head of water is reduced, and there is a corresponding loss of power of the turbines, but since the rise of the stream means an increase in volume, there is a surplus of water. It is therefore possible to begin to run a portion of the water through the current motors, and these may be started, one after another, as the river continues to rise, until the whole battery is in operation and the turbines are out of service.

This plan is not generally advisable for small streams, for in most of them a turbine can be operated all the year in connection with a low dam; nor is it adapted for very deep rivers, because in such cases a low dam would be ineffectual. For rivers in which the low-water depth ranges from 2 to 8 feet, and in which the bed is not formed of deep silt, the plan is well adapted. For an 8-foot river the dam should be 15 to 20 feet high. There are many rivers of this character in which there is sufficient water available for power for thousands of factories, as well as for purposes of navigation and transport. In most of these streams, however, the power now runs to waste because



HORIZONTAL TWIN TURBINE FOR OPEN FLUME, 560 HORSE-POWER, 9-FT. HEAD, 68 R.P.M. PASCO WATER & POWER CO., AINSWORTH, WASH. ALLIS-CHALMERS CO., MILWAUKEE

CONSTRUCTION OF LOCK AND DAM NO. 10 ACROSS THE KENTUCKY RIVER. MASON & HOGE CO. AND RIDDLE CONSTRUCTION CO., CONTRACTORS.
LIDGERWOOD CABLEWAY HANDLING CONCRETE

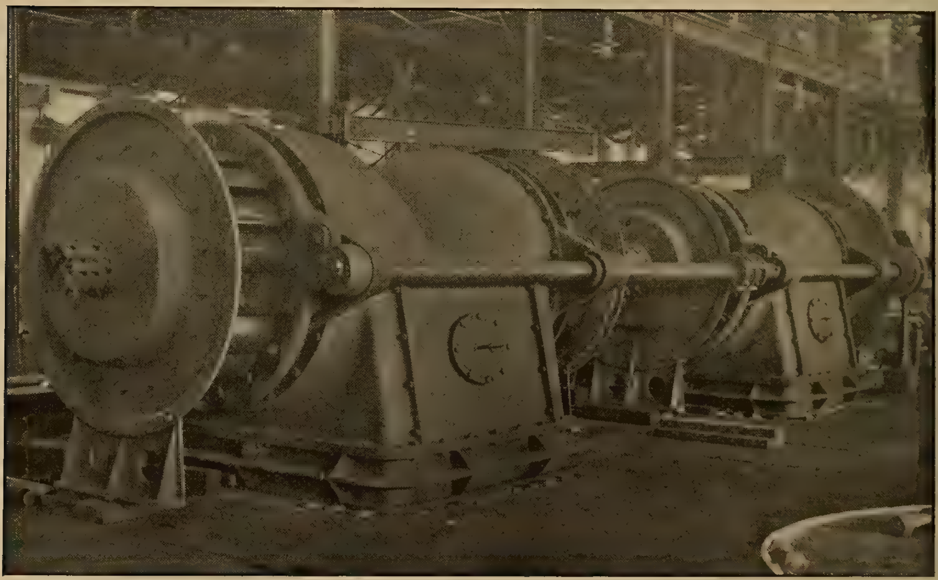
it is assumed that it cannot be utilized without building high dams.

The actual amount of power available in a river can be developed with low dams as well as with high ones. Assuming that dams 10 feet high render available about one-seventh as much power as dams 50 feet high, the intervals between lower dams are correspondingly smaller than for the higher ones. Thus, for a river with a depth of 3 feet during periods of low water, and with a fall of 1 foot to the mile, 10-foot dams could be placed seven miles apart, while an interval of forty-seven miles would be required for 50-foot dams, assuming that the nature of the districts would permit the erection of such structures.

It may be said that in some cases the low dam would not yield sufficient power in one spot, so that the cost of the transmission of the power from several dams to a center of industry would be involved. Even should this be true, the cost of such transmission would probably be overbalanced by the saving in value of submerged land for the low dam, as compared with the higher structure. In industrial localities where the banks of the stream are well populated, the cost of submergence of large tracts of land, including farms, orchards, dwellings, etc., would often render a high dam prohibitory, while a low dam would submerge only the ordinary bed of the stream, or a little more, at any one place.

A succession of low dams would distribute the power development along the river, practically making in many places a continuous town. In this respect this method acts as a system for the distribution of power. The high dam, on the contrary, concentrates the power, often to a greater extent than can be utilized locally, compelling the additional cost of a transmission system to find a wider market. There are many localities in which a dam 5 to 10 feet high would yield all the power which could be utilized in the place.

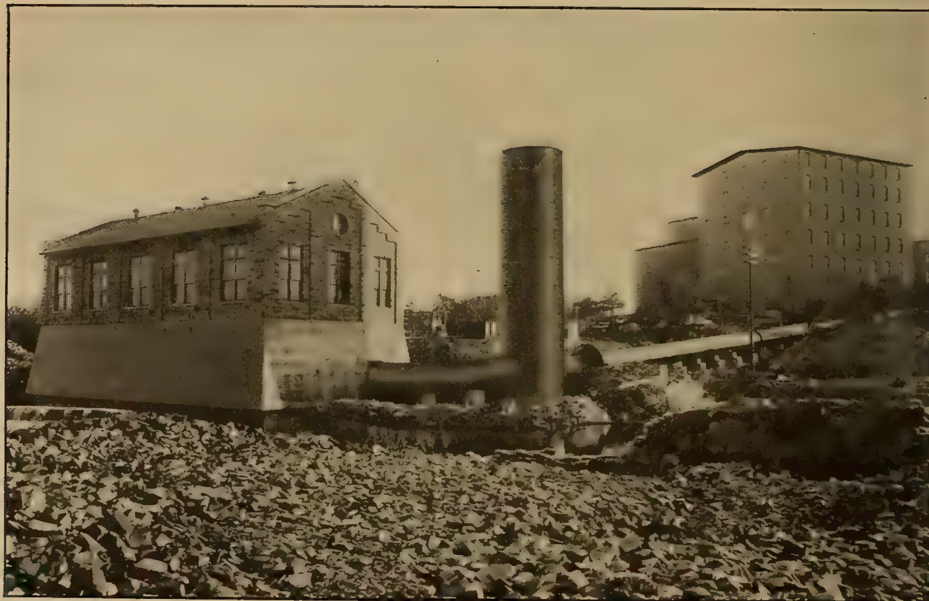
A high dam is always more or less of a menace to the lives and property of people below it, while the danger



FORTY-FIVE-INCH HORIZONTAL QUADRUPLEX TURBINE IN OPEN FLUME, WAUSAU STREET RAILWAY CO. 1,700 HORSE-POWER, 150 R.P.M., 20-FT. HEAD. ALLIS-CHALMERS CO., MILWAUKEE

CONSTRUCTION OF LOCK AND DAM NO. 4, ACROSS THE OHIO RIVER. BAKER CONSTRUCTION CO., CONTRACTORS. LIDGERWOOD RADIAL CABLEWAY HANDLING BUILDING MATERIALS

of this sort from a low dam is very small. A low dam can be built almost anywhere, while a high one demands a proper site. Suitable sites for high dams, such as points where the river passes between high banks, are not always points where power is wanted. If the cost of submerged land be added to the actual construction of a high dam in an industrial district, the relative expense of the high and low dams becomes immensely greater.



POWER HOUSE OF THE SIOUX FALLS LIGHT & POWER CO., SIOUX FALLS, S. D. ALLIS-CHALMERS COMPANY

The construction of dams upon a water course involves delay to navigation, requiring the use of locks, but there are a number of compensations for this objection. Thus, the factories and manufacturing establishments which receive power from the dam form additional sources of freight for the boats.

It is also possible to derive power for the towing of boats from the power plant at the dam. Apart from the question of power, the construction of a series of low dams often includes a marked improvement in a navigable stream, regulating the depth of water and slowing down the current to such an extent as to improve up-stream navigation. If a river is already an important waterway, navigable throughout the year, it is possible that the construction of low dams might injure the navigation more than help it, but such rivers would not generally be used for power development, since the depth of water would render low dams ineffective and high ones expensive.

As a rule, the lower part of a river is good for navigation and too deep or sluggish to be available for power, while the upper portion is too shallow or too swift for navigation, but well adapted for power development. The main advantage of the high dam over the low ones lies in the reduction of delay to boats, a single passage through a high lock taking less time than the several passages required by the succession of low dams.

In considering the improvement of a shallow river by turning it into a deep waterway by the construction of a series of dams, it is usual to take into account the value of the water-

CONCORD ELECTRIC CO., SEWALL'S FALLS, N. H. SIXTEEN-FOOT HEAD, SHOWING WASTE WAYS AND INLET TO POWER HOUSE. ALLIS-CHALMERS COMPANY

power thus developed. In such cases low dams are usually considered, owing to the cost of high ones, and it has been assumed necessary to provide auxiliary steam power for a portion of the year, owing to the fact that such dams would be drowned at high water and half drowned at middle stage. The great additional cost for the installation of a complete auxiliary steam plant, boilers, engines, etc., as well as the necessity for fuel supply, renders such a plan commercially impracticable in most places. By adopting the mixed system of turbines and current motors this portion of the problem is materially simplified.

A running stream may be compared to an endless driving belt, only awaiting connection to the machinery it is capable of driving, but it has not been appreciated because we have become so familiar with it; if it had suddenly been discovered, doubtless it would have been harnessed immediately. Coal smoke mars a town, but hydraulic machinery is not unsightly; coal is passing away, but water flows continuously. A hundred thousand horse-power may be taken from a river and its place is still filled, but the coal vein once emptied is emptied forever. The great waterfalls are limited in number, and many of them remote from civilization, but the power in the running streams is available and at hand.

Current Topics

MR. NEILSON'S paper on the advantages and disadvantages of the use of electric transmission between the engines and propellers in vessels is interesting for many reasons, and upon examination it will be seen that the subject forms really a portion only of a much broader question.

Electricity, in its mechanical applications, is almost wholly utilized as a means of power transmission. This feature is often concealed to such an extent as to cause many men to speak of electric power as if it really formed a department of the subject of power generation, and as if the electric motor was a prime mover in the sense in which that term is applied to the water wheel, the steam engine or the internal-combustion motor. The value of electricity as a means of power transmission lies largely in its flexibility, rather than in any mechanical efficiency which it may possess over shafting, gearing, belting, etc. The whole development of independent electric driving of machine tools has grown up from the facility with which power may be transmitted to any machine almost anywhere, and the ease with which electric driving permits machines to be arranged in the most convenient manner.

Apart from the convenience which is obtainable by using the electric current as a means of transmitting power from prime mover to tool, there are other features which are worthy of consideration. Formerly the determination of the amount of power required for any mechanical operation was a matter of considerable difficulty, involving either the installation of some form of dynamometer or the application of the indicator to the steam engine under successive load conditions. With the electric motor, however, the power may be observed at any time, or, if desired, it may be continuously recorded with little difficulty.

One of the results of this convenience in the determination of power consumption has been the development of machine tools for operation with high-speed steel, the relation between power consumed and work performed being readily found.

It is thus apparent that there are many other points besides immediate economy in power transmission which govern the use of electric distribution of power, and it is often true that the gain, due to better arrangement of machinery, more efficient use of floor space, greater ease of control, and fuller knowledge of power consumption, may outweigh any con-

siderations relating to actual losses in power transmission.

AN interesting development in modern works management appears in the increasing use of recording devices for use in the control of pressures, electric currents, flow of steam, air, and gases, and similar elements in engineering work.

Recording pressure gauges have been in use for many years, and the part which they have played in the continual improvement in steam economy is well known. It is now well understood that the maintenance of uniform steam pressure is an important element in boiler efficiency, and the stoker who knows that a continuous and unimpeachable record of his work is being mechanically maintained under the eye of his employer will do far better than he would otherwise have deemed possible.

With the introduction of electric driving, the recording principle has been extended to the effective use of the electric current. By the use of the recording watt-meter, the power consumed by machine tools becomes a matter of permanent record. Further, it is now possible to observe, in the superintendent's office, just when the important tools are being used, and just how long these expensive investments are allowed to remain idle. There is thus a direct incentive to the foreman to plan his work so as to keep the machine tools busy, knowing, as he does, that the entire day's work is being automatically recorded by an impartial and indisputable observer. The mechanical time recorder keeps tally upon the times of coming and going of the employees, but the newer machine keeps the far more important record of what the men are actually doing after they get to their various stations. The mere moral influence of such records is invaluable, while the importance of past records as guides for future performances cannot be overestimated.

There is little doubt that the use of such recording devices will continually be extended, and that improvements and modifications will be provided to meet the extension of the different departments of industry. Questions which formerly led to differences of opinion, disputes, and deception will be referred to the positive record of the unbiased machine, to the benefit of both employer and employee, and to the advancement of the whole state of the art of manufacture concerned.

THE interest which attends the publication of Mr. Read's article on Siberia in the present issue of this magazine will be increased in the light of the developments of the controversy between Japan and China in the matter of the Antung-Mukden railway line. However the political side of the controversy may be adjusted, it is evident that both nations perceive the importance which is certain to attend the development of the Siberian railway, and the industrial significance of such an additional connection to the main line is of an importance fully as great as its strategic value. The conversion of 180 miles of narrow-gauge track, practically useless for commercial purposes, into a working section of the Trans-Siberian line, with standard gauge and moderate grades, is a matter fully in accordance with the industrial development of Siberia, Manchuria, China and Japan, so fully foreshadowed in Mr. Read's article.

MELVILLE W. MIX

President Dodge Manufacturing Company.

A BIOGRAPHICAL SKETCH.

MELVILLE W. MIX was born November 16, 1865, at Atlanta, Ill., and received his education in the schools of that place, being graduated from the Atlanta High School in 1881, and having worked during the spare time of his school days in the hardware store of his father, Walter H. Mix. For five years after he left school he was occupied as a country salesman, and in January, 1886, he entered the employ of the Dodge Manufacturing Company, at Mishawaka, Ind. Here he worked in various capacities, acquiring a thorough familiarity with the details of the business of making and selling pulleys, shafting, and all the adjuncts of the art of transmitting power by belt, rope, shafting, etc., and in 1890 he was placed in charge of the branch house which the company had established in Chicago. After four years spent in the management of the Chicago house of the Dodge Manufacturing Company, Mr. Mix returned to Mishawaka, to assume the position of general sales manager in the home office.

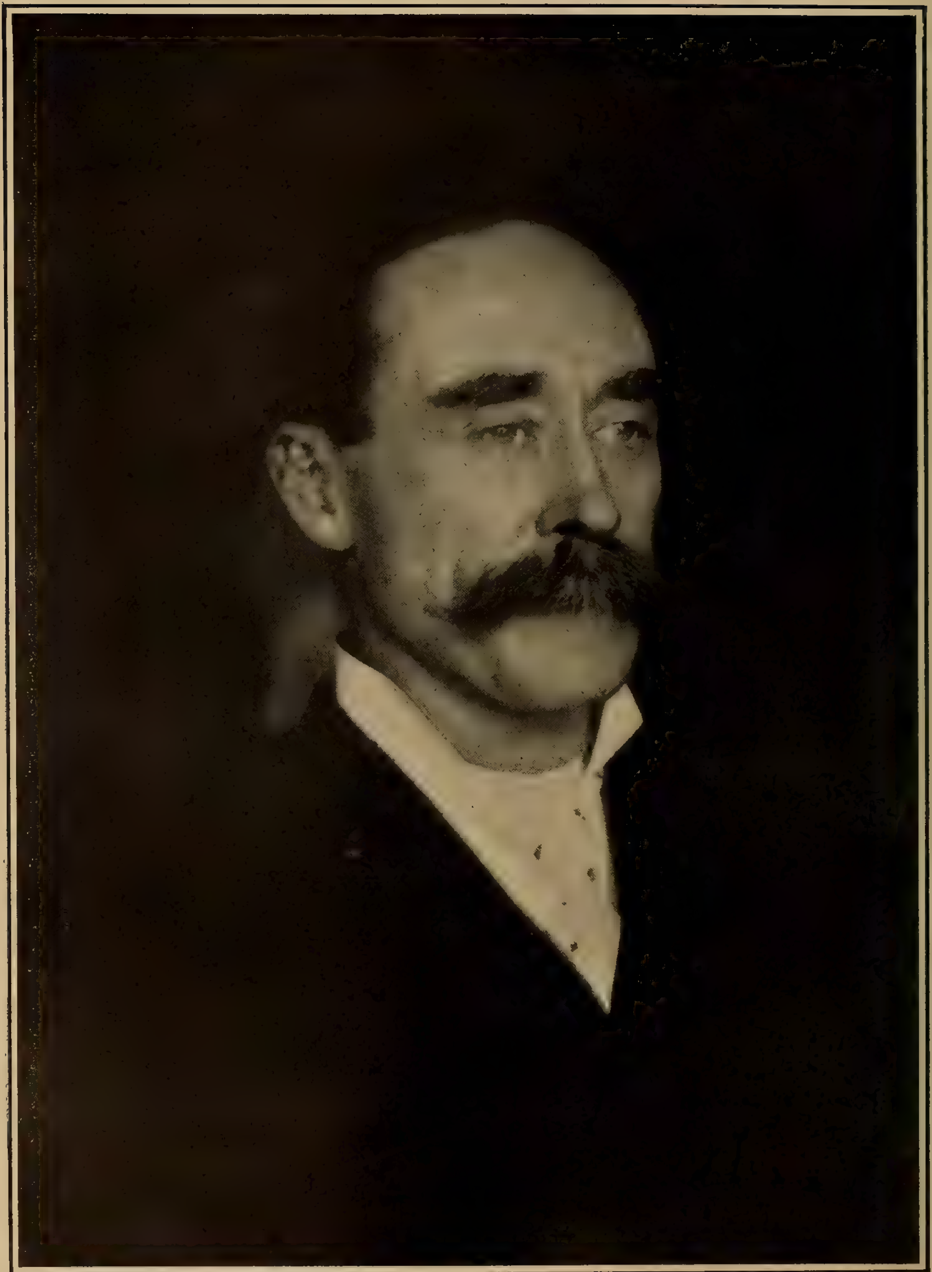
At this time there came the critical period which tested the material of which this young man of twenty-eight years of age was made. Mr. Dodge suddenly passed away, in the midst of the critical period following the panic of 1893, and to Melville W. Mix fell the duty of meeting the crisis and weathering the storm. He was chosen president and general manager of the company in September, 1894, a position which he has held continuously since that time.

To-day, under the management of Mr. Mix, the Dodge Manufacturing Company has attained the position of one of the largest manufacturers of machinery for transmitting power and conveying materials in the world. Its capital has been increased from $250,000 to $1,000,000, while a large surplus has been acquired. Its products, including pulleys of wood and of iron, both split and solid, gearing of all kinds, shafting, bearings, hangers, etc., rope-driving systems, elevating machinery, belt and trough conveyors, water softeners, etc., reach all parts of the world, and the administration of Mr. Mix has brought prosperity and success to the company.

Mr. Mix's success lies largely in his ability to hold a close grasp of business details while not losing sight of the broader aspects of the work, both present and prospective, qualities which, combined with a personality which inspires confidence and enthusiasm, form the highest type of business man.

In addition to his connection with the Dodge Manufacturing Company, Mr. Mix is president of the National Veneer Products Company, president of the Mishawaka Trust & Savings Bank, president of the Mishawaka Public Improvement Corporation, director of the Simplex Motor Car Company, director in the Mishawaka Water Company, and stockholder in other large enterprises.

Mr. Mix is a member of the American Society of Mechanical Engineers, treasurer of the Manufacturers' Bureau of Indiana, member of the Academy of Political and Social Science, and in 1907 he was president of the American Supply and Machinery Manufacturers' Association. From 1902 until 1906 he served as Mayor of Mishawaka.



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COMMANDER ROBERT E. PEARY, U. S. N., CIVIL ENGINEER

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CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XXXVI OCTOBER, 1909 No. 6

THE GREAT OTIRA TUNNEL

By W. Wilson, B. E. (Elect)

THE drilling of a tunnel of more than five miles in length, through the heart of a lofty mountain range, is by no means a common performance; and when, in addition, it is undertaken by one of the British colonies, almost the youngest of them all, the event must have much to interest those who believe in the successful future of the British Empire. The New Zealand undertaking resembles similar ones on the Continent of Europe very closely. The range of mountains pierced contains numerous peaks higher than 12,000 feet, having all the characteristics of the Swiss Alps. Mount Aorangi (Mount Cook), 12,340 feet high, and the Tasman Glacier, eighteen miles long and two and a quarter broad at the widest point, are situated in the neighbourhood. A total length of nearly five and a half miles has to be cut through the hard slates of which the locality is composed, surely a herculean task for a people numbering less than one million. The whole work is being carried out by a New Zealand firm, who are proceeding by means of modern methods and plant that in themselves form one of the most notable features of the whole enterprise.

Before describing the tunnel itself, a brief space may be devoted to the railway in which it forms the crowning achievement. Bold and striking though the "hole in the hill," to use the local name, may be, the rest of the Midland Railway is scarcely less so. From the spot where it joins the existing branch line at the border of the Canterbury Plains to the junction, with the western system at Stillwater, a distance of ninety-two miles, an almost endless series of difficulties has had to be faced and surmounted. Tunnel after tunnel, pierced through the rocky sides of the Waimakariri and Broken River gorges, deep cuttings and high embankments, viaducts on a scale scarcely exceeded south of the Equator, unite to form an undertaking unique except in old-established countries, were it not that the communication between the various parts of the South Island is rendered very difficult, and therefore the progress

of these districts hampered, by the chain of lofty Southern Alps which runs like a backbone from extreme north to south, a feat of such magnitude would never have been attempted. But no other effective method was open for traversing the long stretch covered by parallel lines of snow-clad peaks, and the colonists accordingly went boldly forward to achieve the only possible solution.

At first a private company undertook to do the work, and actually did complete a length at each end of the line, where the ranges are of no great altitude, and the construction, therefore, of minor difficulty. After finishing thirty-five miles of this nature, including three large bridges, one of a hundred feet in height, and several tunnels, they arrived on the eastern side at the gorge of Paterson's Creek, to cross which necessitated another viaduct of about 130 feet. Here they discovered they had underestimated the difficulties before them. They ceased work, became insolvent, and the line passed into the hands of the government, which is now carrying it on. The obstructing gorge was crossed by means of a fine steel structure, the work of a local foundry, and trains are now running to Broken River, twelve miles from the starting point.

THE MIDLAND RAILWAY IN THE BROKEN RIVER GORGE. VIADUCT 190 FEET IN HEIGHT

The line emerges from a tunnel on the right bank, then goes through a cutting over the bridge and then through six more tunnels in rapid succession.

Within the nine miles in the vicinity of these two places, three more important viaducts, all greater than the one first mentioned, have been erected, the largest being that at the Devil's Staircase, no less than 236 feet in height. In addition, there are seventeen tunnels, up to thirty chains in length, besides smaller bridges, fills, cuts and embankments, with scarcely a single stretch of level

CONSTRUCTION GANG AT WORK ON THE MIDLAND RAILWAY APPROACHING THE OTIRA TUNNEL

PREPARING THE EASTERN FACE OF THE OTIRA TUNNEL FOR THE PNEUMATIC DRILL

formation. These difficulties fortunately lessen considerably at the last of the viaducts, and a stiff, though fairly even, grade up the Avoca valley towards Arthur's Pass reduces the task of construction. Much of this section will be open for traffic before the close of this year (1909), and when the last is done on that side of the pass, only the non-completion of the big tunnel will delay through communication with the railroad already at the other mouth; from which point forty miles of permanent way has been in regular use for some years.

Arthur's Pass is the meeting-place of two fairly low but precipitous valleys across the flank of Mount Rolleston, a peak of 9,000 feet. Towards the east, the Bealey Gorge rises from an altitude of 2,500 feet to a total height of 3,013 feet in about a couple of miles, while on the west the famous Otira Gorge descends steep and majestic to its confluence with the Rolleston, at the head of the Otira Valley proper, a drop of about 1,400 feet, in a length of less than three miles. Now it was not always intended to overcome this impediment in the present way. The original company, after considering the conflicting merits of the Abt system and that of Fell, as used to cross the Rimutaka Range in the North Island, decided on a somewhat novel plan, involving far less expense than any other. They simply designed an ordinary railway track ascending on the one side of the pass by the almost unheard-of grade of one in fifteen, and on the other by one of about half that severity. Upon arrival at the foot of the slope, the engine power available was supposed to convey its burden to the top in separate instal-

FIRST SIGHT OF THE DIVIDING RANGE AS THE TRAIN APPROACHES THE TUNNEL. THE PROMINENT PEAK IS MT. BINSER

ments of two wagons at a time. When the summit was reached, these components were to be assembled into a train once more in a specially constructed zig-zag station yard, whereupon the whole would proceed on its way in the ordinary manner. Such a scheme would have absorbed a great amount of time over the journey, and involved enormous wear on the track and rolling stock, besides being fraught with danger to all concerned. For these reasons the government reconsidered the matter on taking the burden upon its shoulders, and abandoned the original proposal in favour of the more expensive but infinitely more satisfactory expedient of a tunnel.

THE RAILWAY IS JUST ABOUT TO PLUNGE INTO THE ALPS. THE ROLLESTON RIVER IS SEEN AT THE END OF THE CUTTING

The first step was to decide upon the most economical route, and for years engineers and surveyors toiled ceaselessly up and down the rugged crags and bush-clad slopes of the pass, collecting data for the solution of the problem. Several alternative proposals were made as the result of this work, the length in the various cases ranging from five to eight miles. At last one, the ultimate suggestion of Mr. Hay, the government engineer, was selected, and is now being vigorously advanced on its way. It has the great advantage

MOUTH OF TUNNEL OTIRA

VIEW FROM DIRECTLY OVER THE MOUTH, SHOWING THE BRIDGE OVER THE ROLLESTON GORGE, AND TUNNEL WORKSHOP IN THE FOREGROUND

of being comparatively short, and, at the same time, involves no steep climbing to reach the approaches. From end to end it is a straight line, and this consideration, together with a favourable geographical position, simplified the operation of alignment very materially. The grade throughout is one in thirty-three, but as electric locomotives will almost certainly be employed to take the trains through the mountain, no inconvenience nor danger will result on this account. Altogether there is no doubt that the best possible site has been chosen, and the high first cost involved in its selection will be repaid many times over.

The tunnel enters the mountain side about half a mile from the great Devil's Punchbowl waterfall, and then passes immediately under it, on its course downhill. It next burrows beneath the summit of the pass, and, after running under the Otira Gorge, it emerges from the rocky wall of the Rolleston Gorge about three-quarters of a mile above its confluence with the Otira. A substantial steel and concrete bridge conveys the railway across the river to a steep cutting on the left bank,

MOUTH OF TUNNEL AS SEEN FROM ACROSS THE GORGE

Note the surveyor's line marking the line of the tunnel going over the spur.

and a run of about two miles brings it to the present terminus of the Westland section.

The situation of the tunnel mouth at Otira, where most of the work has so far been done, is an exceedingly romantic one. Though but a black hole in the "bush" at the base of a snowy peak, its insignificant appearance is quite balanced by the signs of internal activity observable all round it. In front is a broad platform composed of broken material from the interior, and, at frequent intervals, a loaded truck will emerge swiftly from the darkness, rush to the tip-head, and shoot its load over the edge, thereby extending the area till a good-sized station-yard is in existence. Lines of rails radiate in all directions, on which a petrol locomotive and horses are busy shoving and hauling trucks of spoil or stores. Round the mouth are grouped a number of buildings. There are two compressor houses for supplying air at a pressure of a hundred pounds to the square inch to the pneumatic drills in the tunnel. One contains the old steam pump, which did duty until the completion of the electric plant rendered it obsolete, except as a reserve. The other is a large building in the river-bed just below, connected by a line of poles and cables, with a similar structure across the gorge, whence comes the electric current

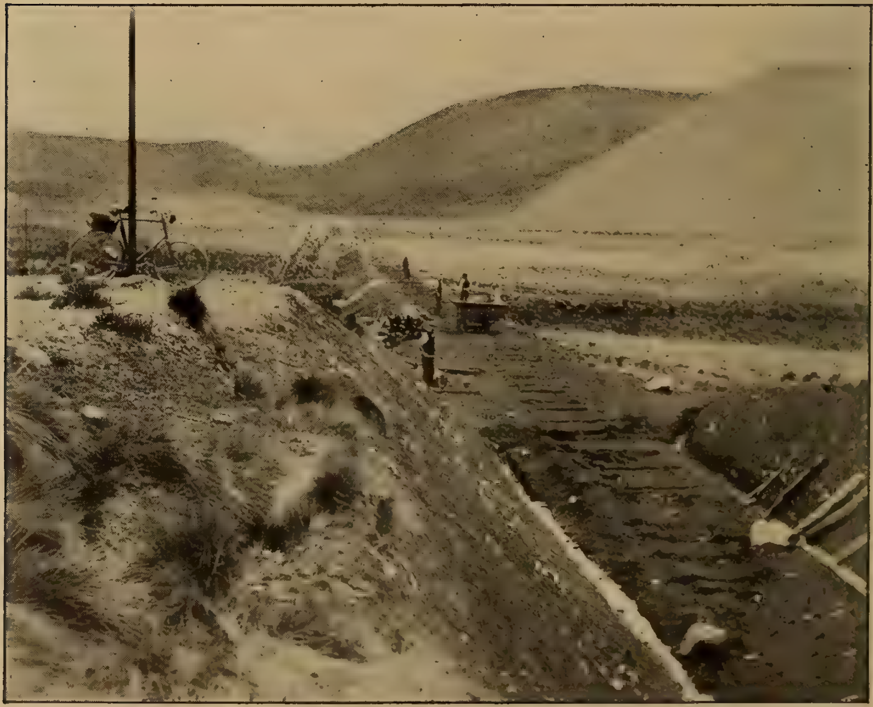
A DRILLING PARTY BEGINNING THE TOP HEADING

A TUNNEL ON THE MIDLAND RAILWAY

The permanent way is being formed of concrete on the side of the gorge. There is a 190-foot drop from here to the water.

THE FIRST OPERATION, CLEARING THE SURFACE AT THE EEALY END TO EXPOSE THE FACE OF THE ROCK

THE WORKING FACE OF THE TUNNEL, SHOWING DRILLING MACHINES AT WORK



AN EASY STRETCH ON THE MIDLAND RAILWAY

which supplies the whole of the works with power and light. There are also a fitting shop, smithy and carpenter's shop, a concrete factory, a set of bathrooms, where the men may have hot and cold plunges or showers at any time of the day or night, a drying room for the miners' clothes, and a stable. On a terrace about fifty feet above the yard are the managers' and engineers' houses, and the offices, while scattered in picturesque situations all about the gorge are the quaint, little dwellings of the employees, some of which are very prettily furnished and ornamented by means of timber placed at their disposal by the management.

Inside the tunnel the main scene in all this activity is being enacted, and to witness this a walk of about half a mile, the present length of the drive, is necessary. As we approach the end, a quick, half gasping, half thudding noise is heard, growing louder and more distinct, and, at length, we come upon several machines which, to the uninitiated, may be considered as resembling Gatling guns attacking the solid rock, the sound of their blows suggesting the action of rapid-fire artillery. These are the pneumatic rock drills, operated by compressed air, led into the tunnel through a steel pipe connecting with the com-

THE OTIRA GORGE, UNDER WHICH THE OTIRA TUNNEL RUNS

THE DEVIL'S PUNCHBOWL (700 FEET), SHOWING PIPE LINE BY WHICH WATER IS BROUGHT DOWN TO POWER HOUSE BELOW

ON THE HOLT'S CREEK TRACK. STEEL PIPES BEING TAKEN UP THE FALL FOR SUPPLYING THE POWER HOUSE, 700 FEET BELOW THE INLET

pressors outside. The steel drills are kept pounding away at the hard rock until the holes are about six feet in depth, and twelve such holes are drilled for each blast. Charges of gelignite are then inserted, and after the blast has been fired the debris is removed and the machines advanced for another six feet.

At the foot of a huge rift torn in the side of the gorge, directly opposite the mouth of the tunnel, by a mountain torrent called Holt's Creek, is the power station. A large steel pipe, winding like a great snake up the gulch from a dam 700 feet higher, enters the back of the building, and yields 600 horse-power to

A STEEL PIPE LINE DESCENDING HOLT'S CREEK GULCH TO THE OTIRA TUNNEL POWER HOUSE. 600 HORSE-POWER AVAILABLE

In this way three shifts of workmen can excavate about eighty feet per week of six days, from the one end. At the other, or Bealey end, drilling was not begun at the time of writing, but by the middle of the year equal progress should be made from each end.

Pelton wheels, which drive dynamos connected directly to them. Thus Nature is made to supply ample power for all purposes, and the otherwise heavy coal bill is quite obviated. At the other mouth, the Devil's Punchbowl is tapped before it plunges over its sheer leap of

THE BEGINNING OF A BIG VIADUCT ABOUT 150 FEET IN HEIGHT. MIDLAND RAILWAY

nearly 800 feet into the Bealey River below. An exactly similar power-house to that at Otira has been erected near the base of the fall, and will enable all work here to be done equally cheaply and efficiently.

Leading over the hill above the tunnel is a line indicated by a narrow clearing of the forest. This marks the exact line of the tunnel and runs vertically above it from end to end. On the accuracy of this line depends the exactitude with which the two portions of the works will meet, in the heart of the range. Enclosed in shelter-sheds at each end, so as to be seen from inside the tunnel itself, are points which are exactly on the centre line, and it is largely by means of these that the engineers, once a fortnight, survey the work done and keep it from deviating to one side or the other. The directing of the two drives, so that they proceed infallibly towards each other, is the most impressive feature of the whole undertaking, and, when we realize that after five years' steady approach they will eventually meet, correct to within a few inches, we cannot help feeling amazed at the triumphs of modern engineering.

POWER PLANT WASTE

By Percival R. Moses

THE importance of the prevention of waste in the operation of private and central power plants has hardly received its due share of attention in the discussion going on all over the country on the prevention of waste in national resources.

It is true that the United States Geological Survey has recognized the importance of one waste—the waste of fuel—and has vigorously called attention to the fact that out of from 12,000 to 14,000 heat units available in each pound of coal hardly 1,200 are actually turned into work in the central station, the remaining thousands going into the condenser and river. The private or isolated plant is but little better off, except during the seven months of the heating season.

The gas producer and the gas engine offer to the user who has no great use for his exhaust steam a means of economizing in the use of fuel, and this possibility is being rapidly appreciated.

The waste of fuel, however, as determined by the type of engine or boiler used is only one of a great multitude of wastes going on continually in the operation of every public and private plant, and it is the purpose of this article to describe some of the wastes found by the author in his practice and the means taken for correcting them.

The wastes may be divided into two main classes: Those due to improper design, and those due to improper operation. The former are more important, because they are more difficult of correction, but the latter are usually more costly unless they are corrected.

The main wastes in power plant operation are waste of fuel, of labor, of water and of oil. These are the main wastes, because they are the main items of cost.

As pointing to the fact that these wastes are matters of dollars and cents, and not theoretical, it may be stated that every one of the wastes noted hereafter has been actually seen by the author, and a great many of them will be found by any investigator in almost any plant visited. The aggregate amount of waste in the operation of plants must be an enormous total; how much, it is impossible even to guess, but some idea may be had from the statement of the United States Geological Survey that: "The total consumption of coal in St. Louis, Mo., for industrial purposes alone amounts to more than 5,000,000 tons annually. If gas producers and gas engines were substituted for the steam plants this tonnage would be reduced 2,500,000 to 3,000,000 tons, and, at the same time, smoke would be practically eliminated.

This is a possible saving of waste in fuel alone, and only in the matter of fuel used for engine operation.

Now, consider the multitude of wastes involved through inefficient steam pumps, steam elevators, steam-heating systems operated by live steam, steam-drying systems operated by live steam when exhaust steam would suffice, and the other methods of steam-heating wastes, and then add to these the wastes of water, the wastes of oil, and the enormous labour wastes, and some idea of the

total for a single city may be imagined.

Taking up these wastes in their usual order of importance, the waste of fuel will be considered first.

It is not the purpose of this paper to go into details of comparison between the gas-engine plant and the steam-engine plant, but the case between the two may be stated briefly as follows:

On a straight power proposition of one or two thousand horse-power or less and where no steam is required for manufacturing or heating, the gas-engine plant uses from one-third to one-fourth as much coal as the steam-driven plant; but, with the exception of central stations for light and power only, a plant where no steam is used for heating or manufacturing is a rare occurrence, and each problem requires to be figured out for itself.

If exhaust steam from the engine can be used, either in whole or in large part, it is probable that a steam plant would be advisable; and, in general, if 50 per cent. of the steam available from steam engine operation can be used, either the plant should be all steam or it should be a combination of a steam plant and a gas plant. It is probable that the future manufacturing plant will consist of this combination.

The writer is now designing a plant of this kind for a malleable iron foundry, where it is intended to use the very fine particles of coal for the steam plant, and a somewhat coarser grade for the producer gas plant. The steam plant in this particular instance will derive part of its steam from the waste gases of a reverberatory furnace, and the exhaust from the steam engines will be used to heat the building. The gas producer and gas engine plant will supply most of the power required, with the exception of the peak load, and the exhaust gases from the gas engine will be used to heat the feed water required for the boilers of the steam plant.

In general, then, the fuel waste due to the inefficient means of transforming the energy of the coal into power may be avoided or greatly reduced by sub-dividing the plant into high-efficiency gas engines and steam engines, which also become of high efficiency when their exhaust can be used.

Considering, now, the steam plant distinct from the gas engine and producer plant, the fuel wastes of common occurrence are as follows:

Excessively high-cost fuel may be necessary because of defect in the design of boilers, grates or chimney, *i. e.,* the boilers may have heating surface insufficient to take up the heat, which is at a somewhat lower temperature where low-grade fuel is burned than where high-grade fuel is burned. Or. if there is sufficient heating surface in the boilers to take up the heat, the grates may be too small to allow of burning efficiently this small-size fuel. Grates for the use of small-size fuel, which is the same as low-price fuel, should have at least 1 square foot of area to every three horse-power of rated capacity. This allows of overload capacity with the proper size of stack. This brings up the third way in which the design may prevent the burning of low-grade fuel, *i. e.,* the stack. If the stack is not high enough or has not area enough it becomes necessary to burn more expensive, higher grade coal, which, while it may have 10 per cent. or 20 per cent. more heat units than the smaller, low-grade coal, costs double as much per ton and is, therefore, far less efficient to burn.

This is one of the most important wastes in the use of fuel: The use of a fuel of too high cost. If the grates are too small, and it is not possible to enlarge them without making the furnace too deep, mechanical draft will overcome the difficulty. In fact, mechanical draft for manufacturing and similar plants is a good thing, because it tends to stir up the coal and to create more

perfect combustion, and the installation of a blower is further advisable to take care of a poor run of coal or of the peak load.

The design of grates is an important item in the economical operation of a plant. The size of air space should be suited to the quality of the coal and kind of coal burned. If it is not, it will result in serious waste, either through dropping of coal into the ash pit or through imperfect combustion of the fuel. The first shows up in an inspection of the ashes and the latter in the quality of the flue gases.

With the stack all right, with the boiler having sufficient heating surface to take up the heat, and with grates designed for burning low-grade fuel, loss may still occur and does occur through excessive radiation through the boiler setting. In order to cheapen the first cost of construction, boiler walls are made insufficiently thick and drums and shells are not properly covered, resulting in a continuous loss through excessive radiation, which is of moment because it is continuous no matter what the load may be on the plant. A wasteful engine, which is only operating a few hours a day, is not nearly so serious a cause of waste as a wasteful boiler setting which is in operation twenty-four hours a day.

In the operation of a boiler, preventable wastes are those due to fouling of the heating surface, *i. e.*, the tubes and shell, both inside and outside, allowing the gases to go out through the chimney without parting with some of their heat.

A poor fireman is a most expensive article of luxury. A man who throws on great quantities of coal at a time, allows his fire to get spotty and thick, and does not maintain his water and steam approximately constant, may add 20 per cent. to the fuel bill and is worse in a plant than the most inefficient steam engine.

Sometimes a short circuit is found in the boiler setting—*i. e.*, the gases instead of traveling in their orderly path either over and under sets of baffles as in water-tube boilers, or under the shell and back through the tubes as in a horizontal return-tubular boiler, find openings that allow them to escape directly to the flue without doing any work. This not only wastes heat but is also liable to damage parts of the boiler exposed to the direct flame if these parts are not touched by water to carry off the heat.

In connection with the operation of boilers serious wastes, easily preventable, are caused by the failure properly to pre-heat the water fed to the boilers. Where fuel cost is high and the steam pressure carried is more than 100 pounds per square inch, the use of an economizer is an economic necessity. The water on its way to the boiler should first be heated in an ordinary feed-water heater somewhere near 212 degrees Fahrenheit and then pumped through the economizer, where it should be raised as nearly as possible to the temperature of the water in the boiler. It is quite possible to get within 60 degrees to 70 degrees of the temperature of the water in the boiler; certainly to within 100 degrees. As an example of actual conditions, a large smelting plant may be instanced where, with fuel oil costing 3½ cents a gallon, feed water is introduced into the boilers at 62 degrees Fahrenheit, when, by the use of a feed-water heater and an economizer, the temperature could be easily raised to over 300 degrees, and a saving of nearly 20 per cent. in the fuel effected.

In connection with the subject of the use of low-price or low-grade fuel, it may be stated generally that with proper design and operation the lowest-price fuel is the most economical to burn. This is a fact rarely recognized, and it is a common statement among engineers and laymen that "the best is none too good for us." They forget, however, in making this statement that the reason the

low-price fuel is low in price is not because of any lack of heating value, as a general thing, but because it requires special design and arrangements to burn it. Hence, the demand for the larger, high-priced fuel is more general and the price is higher. It is only a question of demand, and not a question of quality, that fixes the price. Sometimes insufficient boiler capacity makes it necessary to burn a high-price fuel merely to get the 20 per cent. extra heating value contained in it, even at the excessive price of 100 per cent. extra cost. But this is a fault either of poor design or failure to keep up with the growth of the business. Waste in boiler design and operation is waste in the production of steam.

Wastes in the use of steam are more numerous because there are more pieces of apparatus to use steam than there are to produce it. Without going into the finer details of engine and plant design, there are certain crude wastes that are met with every day, and to which attention should be called, as they are easily preventable.

One of the most frequent wastes is in connection with the cut-off valves of the engine. These valves are supposed to cut off steam absolutely at a certain point in the stroke of the engine, depending upon the load. If they do not shut off the steam, it is evident that steam will continue to blow into the engine and out through the exhaust port as soon as it is opened. During the past year, out of thirty engines examined, over twenty had leaking valves, and even engines ready for shipment from responsible shops, when the cylinder heads were taken off, showed volumes of steam pouring out with the valve in the closed condition. If the valves are tight the piston may leak—*i. e.*, the rings will no fit properly to the cylinder walls—and the steam, instead of doing the work of pushing the piston, will escape around the piston without doing the work that it should.

These defects are hard to recognize by the indicator cards, unless of great volume, and the best way of finding them is to open the cylinder by taking off the head and placing the valve in the closed position and see if it is tight; place the piston at one end or the other of its stroke and see if it is tight, and if it isn't make it so. A saving of 20 per cent. of the amount of steam used by an engine has been made several times by just attending to this one detail. In some engines, the design of the valves is such as to make it almost impossible for them to stay steam tight—*i. e.*, an excessive pressure is allowed to come on the back of the valve, causing it to cut as it is moved rapidly backward and forward across the valve seat. Throttle valves that leak are also sources of preventable waste.

Minor wastes in connection with engines are those due to improper proportioning of the engine cylinders —*e. g.*, the diameters may be too great in proportion to the length of the stroke, causing excessive radiation on account of excessive clearance space necessary. Imperfect lagging or covering of the engine cylinders is not only wasteful but adds greatly to the heat of the engine room.

The design of the engines as a part of the whole system of the building has an important bearing on the fuel economy. As explained elsewhere in this paper, the steam engine is a very perfect piece of apparatus where the exhaust steam can be wholly used, but where its exhaust steam cannot be used it is a very imperfect piece of apparatus, and a very wasteful method of transforming the energy of the coal into power. Hence, in designing the engine system of a manufacturing building or plant, if the whole plant is to be steam operated, it is not necessary that all of it should be either non-condensing or condensing. In fact, it is often advisable to di-

vide the plant in such a manner that a sufficient part of the apparatus runs non-condensing to supply the necessary exhaust steam. Sometimes we find plants using live steam entirely for such uses as drying and evaporation which could be done equally well by exhaust steam; and at the same time a large steam plant is operating condensing. In such a plant a saving could be obtained by operating the plant partly condensing and partly non-condensing.

On the other hand, we find large plants operating entirely non-condensing where the exhaust steam can only be used in small part during a part of the year.

The engine plant should be subdivided, so as to avoid the necessity of running a large engine to do a small engine's work. One instance, recently investigated, showed excessive operating cost because a 400-horse-power engine was running 24 hours a day, using over $80 worth of fuel for a load of less than 75 kilowatts, merely because there was no small unit on the plant capable of taking care of the light load economically. In this case the loss was aggravated by the high cost of the fuel.

Similar wastes are to be found in design of pumps, air compressors and refrigerating compressors. The use of small simple duplex or simplex steam pumps, where their exhaust cannot be fully utilized, requires from two to three times as much coal per horse-power of work done by the pumps as would the use of electric-driven pumps of good efficiency. The use of simple pumps, and even compound steam pumps, for large work, instead of crank and fly-wheel pumps or high-duty pumping engines where the steam is used expansively, is equally wasteful. The use of steam in the ordinary simple steam pump always reminds one of the saying "Sheer strength and ignorance."

In the design of heating, drying and evaporating systems, fuel wastes occur in many ways. The most frequent source of loss, perhaps, is the installation of insufficient surface involving the use of high-pressure steam, where, with the proper amount of surface installed, low-pressure exhaust steam could be used with equal results. In one of the largest hospital plants in New York City thousands of gallons of water have been heated daily by steam directly from the boilers, while the exhaust steam from the engines was going up through the exhaust pipe to the outside air, simply because insufficient heating surface had been provided for the hot-water tanks to allow the use of exhaust steam. At this same hospital another waste was found which is also of frequent occurrence. That is, the water condensed in the heating system was allowed to discharge into the sewer, because the engineer said he could not save it because of oil in the steam, and this is the usual reason given for wasting the returns. At one of the large department stores the same state of affairs was found, as well as at other places. Of course, the fact of the matter is, that there are many devices on the market for taking the oil out of the exhaust steam, which work perfectly satisfactorily, and in ninety-nine cases out of a hundred the returns are saved; but in these few instances, through failure to make the comparatively light expense for the apparatus (necessary in every other case as well), they had gone on year after year wasting money by letting the condensed exhaust steam flow into the sewer.

In a manufacturing plant where steam was used for drying lacquered articles and for keeping solutions hot, the same state of affairs was found. Boiler steam was used, but since the pipe-coil surface has been increased both these processes are done by exhaust steam from the engine in a perfectly satisfactory way.

In the evaporation of solutions,

such as brine, etc., great economies are obtained by the use of the multiple-effect process. In this process, a number of vessels containing the solution to be evaporated are connected together in such a manner that the vapour made in one vessel enters into the heating coil of the next and evaporates the solution in the next vessel, the vapour from this vessel going on to the third vessel's heating coil, and so on. By carrying a different degree of vacuum in each vessel from three to four times the work can be gotten out of the coal than can be gotten out of the fuel in straight evaporation where the vapour or steam from the evaporating vessels is wasted. For many years, and even now in a great many instances, salt brine is evaporated from single vacuum pan, where by the installation of a multiple-effect system from two to three times the work could be obtained from the fuel.

In connection with the operation of ventilating and heating systems in schools, clubs and manufacturing buildings, there are long periods during the twenty-four hours throughout the year when ventilation is not required, but when heat is required to make up for losses through walls and windows to prevent the buildings from cooling down. A frequent and wrong method of installing these systems is to provide that all the air for heating and ventilating the building be taken from outdoors and discharged through heating coils to the various rooms to be heated, with no other means provided for heating the rooms, so that even if no body is in a room, all the air has to be taken from outside at the outside temperature and heated 70 degrees or 80 degrees or 90 degrees, as the case may be, and discharged into the room. If, instead of doing this, provision was made either for re-circulating the air in the building when ventilation was not required, or for heating the rooms by direct radiators strung alongside the rooms, this waste of heat would be avoided.

The use of exposed steam risers and mains saves the first cost of covering, but is a continual source of waste forever afterwards, because the surface of these exposed mains and risers give out heat whether it is required or not, as long as there is steam in the system. Although the total waste in this manner may not exceed 20 horse-power a day, it is going on for 10 or 12 or sometimes 24 hours a day for perhaps 100 days a year when there is no need for it.

Where refrigeration is needed, the use of either the absorption system with the generator supplied by exhaust steam, or of a combination of compression and absorption system with exhaust steam pressure used to operate the generator of the absorption system, offer marked economy over the straight compression system, particularly so as the greatest use of refrigeration comes in the non-heating system when the exhaust from the electric plant would otherwise be but little used.

Leaks of all kinds, whether of steam, feed water or drip, are fuel eaters. Leaks of valves and traps (and each trap usually has three valves forming a by-pass around it besides the regular valve of the trap itself), as they are concealed, often go on for long periods unnoticed. In one instance, investigated lately, various traps were discharging continuously through their leaky valves to such an extent as to create a back pressure on the feed-water heater. This feed-water heater was of the open type and was provided with an overflow and a loop seal sufficient to hold against a pressure of 5 pounds. The trap discharge, however, created a pressure in excess of this amount and the consequence was that a stream of water flowed out of the feed-water heater continuously and to such an extent that water could not be obtained on the upper floors of the building. This led to an investigation, and the trouble

was found to be just as stated.

High-pressure drips are usually saved; low-pressure drips are wasted because they contain oil. Perhaps it is well to waste a good many of these oily drips, but their heat can be saved by running them into a tank provided with a cooling coil.

In a manufacturing plant, the application of the transmission of the power from a central source usually offers, unless it be one recently designed, a very fruitful field for saving. Sometimes it is long lines of steam pipes with high-speed engines at their end, equipped with inefficient slide valves, operating through belting, long lines of shafting, and in such an installation probably 60 per cent. of the total power generated is wasted. Of course, this waste of power means waste of fuel. The substitution of electric drive for a wasteful steam engine and steam piping will cut off a great deal of this waste, and sub-dividing the shafting will reduce it still further. In each case, it is a question of how much economy can be effected, and whether the expense is warranted.

In a new plant, it is almost always found that the electric drive is preferable and but little more expensive than the wasteful drive, but in an old plant it is a question of scrapping the old machinery, and, hence, the electric-drive cost is entirely extra.

In connection with electric operation, the efficiency of motors is not given due consideration, and while it is folly to put in motors of too small a size for the work to be done, it is equally poor engineering to put them in much too large. In both cases waste of fuel results. It is better to put in motors that are too small than motors that are too large, so that, if the load is found to be too heavy, the work can be subdivided and additional motors installed.

In connection with the lighting of buildings, waste of fuel results both from poor illuminating engineering and from the use of low-efficiency lamps. By careful choice of the kind of light and proper provision for its reflection the quantity of electricity required to illuminate a given building can be reduced 50 per cent. to 70 per cent. below the amount required without such care in design.

In some buildings we find 240-volt lamps requiring 4.5 watts per candle power, and the wiring system so designed that only such lamps can be used; while, if this system were properly designed, Tantalum or Tungsten lamps could be used at from 110 to 120 volts, the Tantalum lamps requiring 2 watts per candle power and Tungsten lamps 1¼ watts, or less than 30 per cent of the amount required by the 240-volt lamps. If this fact were taken into consideration at the time of design of the plant, not only would there be a saving in fuel cost, but also a saving in first cost of the installation.

In buildings where the lighting load is one of the principal features, as it is in hotels, apartment houses, office buildings and similar structures, by designing the lighting so that the exhaust steam from the plant is seldom in excess of the heating requirements, the operation of the electric plant becomes almost a by-product of the heating, and the amount of coal used in winter for these buildings is very little different whether a heating plant is operated or whether a heating and lighting plant is operated, because in the latter case the exhaust steam from the plant heats the building, whereas in the former case steam derived directly from the boilers is used.

A comparison was recently made between three office buildings in New York City, one of which contains an electric plant, the second a refrigerating plant but no electric plant, and the third a straight heating plant. The amount of fuel required by each one of these buildings during the month of January was as follows:

1. Electric and heating plant fuel consumption during January, 1909......... $381.70
2. Refrigerating and heating plant fuel consumption during January, 1909.. $346.32
3. Heating plant fuel consumption during January, 1909............ $316.05

It is evident from this comparison that the question whether an electric plant or a refrigerating plant was operated had very little to do with the amount of fuel used in the building, the amount being largely determined by the quantity of coal required to heat the building, and it made no difference whether the steam was first passed through an engine or not.

In connection with a gas engine and producer plant, the main wastes occur through the heat lost in the jacket-water and in the water used to cool the cylinders of the engine, the heat wasted by the exhaust gases and the heat contained in the carbon-monoxide gas or the water gas carried over from the producer to be burned in the engine.

As many of the plants installed in this country were originally of small size, little attention was paid to these wastes and the jacket-water was allowed to run to the sewer or was cooled and re-circulated if water was scarce, and the exhaust gases were allowed to go out into the atmosphere at 1,000 degrees or thereabouts. But attention is beginning to be paid to these wastes, and boilers are installed now to take up the heat from the exhaust gases on their way to the outside air, and the jacket-water is used to supply these boilers, so that it is now possible to make about one-tenth of a horse-power of steam for every brake horse-power of gas engine by utilizing these two waste products.

This possibility of saving the heat in the jacket water also applies to a lesser extent to all apparatus requiring water for cooling the cylinders of the engine, such as air compressors and refrigerating machines. It is not always possible to use the heat thus obtainable; but when it is possible it should be done.

In connection with foundries, smelters and blast furnaces, competition has caused more careful investigation of the possibility of utilizing the waste products of these processes, but, as it would require an encyclopedia to go into all the possible by-products the utilization of which would save fuel, it will merely be stated here that failure to use such waste heat or by-product of manufacture is a serious and not infrequent source of preventable waste of fuel use. As an example of this, in making a report on a large foundry plant recently, four distinct sources of waste were found, one of which alone was capable of generating 100 horse-power just at the time it was needed for blowing up two cupola furnaces, and the saving of this waste not only would reduce the fuel cost, but would also prevent the excessive wear and corrosion of the stack, which is now subjected to temperatures of 1,000 degrees to 1,500 degrees. This particular waste was in connection with an air furnace used in melting iron, and in this furnace hardly 20 per cent. of the available heat of the fuel was utilized, the rest going out the stack.

It may be safely stated that in a great majority of the plants in operation to-day 20 per cent. of the fuel cost could be saved by preventing waste, and in some instances actual savings have been made of 50 per cent. Such savings are usually obtained without any great initial expense, as the losses are caused by simple things, such as leaky valves, poor type of grates, or some of the other causes mentioned herein, which are easily preventable at small cost.

(To be continued.)

CONCRETE PILES

By J. F. Springer

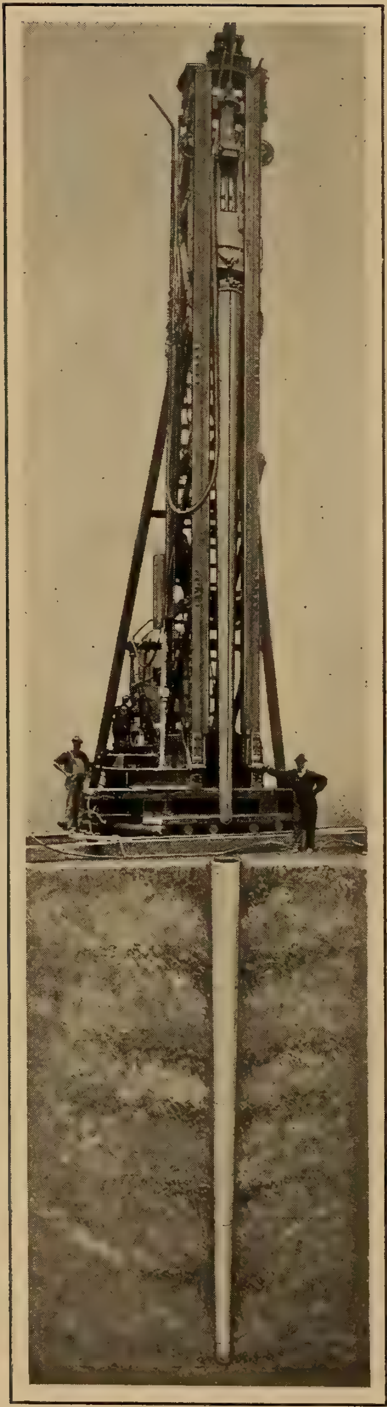
II.—DIFFERENT METHODS OF DRIVING PILES

This is the second of two articles on this subject. In the first one the construction of foundations upon corrugated and moulded piles was described, while this one treats on the methods of driving piles and describes the various standard makes.

RECENT DRIVING WITH THE WATER-JET.

THE process of using a hydraulic jet has been applied where no grooves were arranged on the exterior of the piles for the return current. A recent example of this procedure relates to the construction of a power plant in Cambridge, Mass. Forty-odd foundation piles were used. These were 30 feet 6 inches long, square in cross-section, and tapered from 14 x 14 inches at the head to 9 x 9 inches at the foot—except a few, which were tapered to slightly different foot dimensions. In the Gilbreth system, the central core is withdrawn subsequent to casting and prior to driving. Messrs. Thompson and Fox, the engineer and contractor in charge, departed, however, from this method and placed galvanized iron piping permanently in their piles. The tubes ranged from 1 to 2 inches in size. In some of the piles, two sizes of pipe were employed—that having the larger diameter being arranged at the upper end of the pile. At the very bottom of the jetting pipe, a reduction of diameter was made to increase the velocity of the stream and so render it more effective. It is said that, with the water flowing freely, clogging of the nozzle will not occur. It is thought that if this nozzle be made a foot, or, if it seems preferable, two feet in length, sufficient precaution will be taken to prevent choking. The reinforcement consisted of longitudinal rods bound with loops. The longitudinal rods were of ⅞-inch corrugated steel, and the loops of ¼-inch. At the upper end of the piles, the loop reinforcement was increased in order to strengthen this portion very considerably.

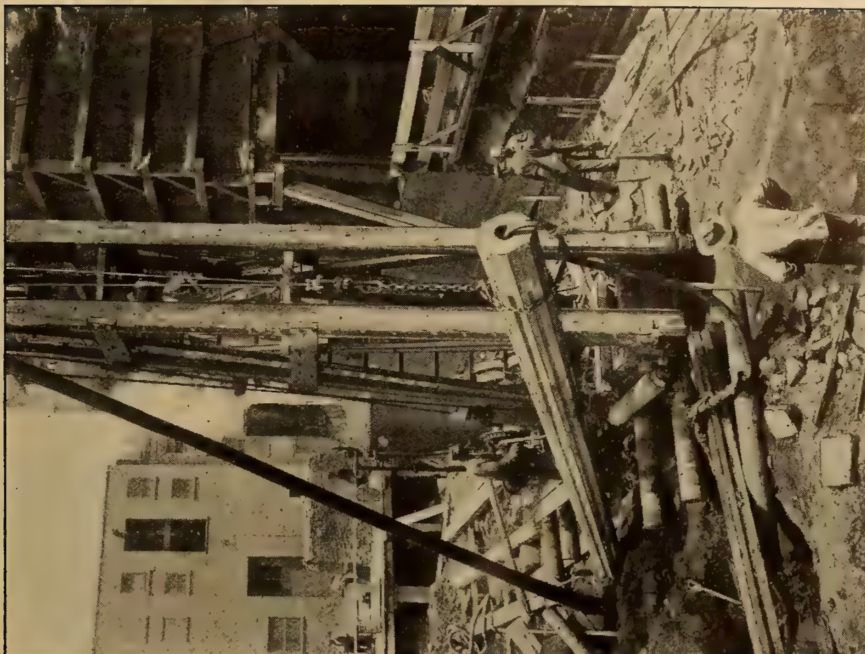
When the piles were cast and had aged about a month, they were driven into place by a combination of methods. The varied nature of the soil was largely responsible for this. At the surface is a layer of ordinary filling about 6 or 8 feet deep. Then, for a distance of about 30 feet is a stratum of sand. Finally, there is a layer of hardpan (clay). The water-level is about 6 feet below the surface of the ground. In driving, the usual procedure was to set up the pile in position and turn on the water-jet after connecting up. The action of the jet, assisted by the weight of the pile, was generally sufficient to cause a short penetration. By resting the driving weight of 4,700 pounds upon the cushion which surmounted the head and continuing with the jet, a further piercing of the soil could often be accomplished. However, at about this stage, the churning process would be adopted. That is to say, a chain connection would be so arranged that when the weight was lifted the pile itself would be slightly withdrawn. When the weight was released, it would first strike the loose pile, whereupon the two together would



RAYMOND CONCRETE PILE CASING DRIVEN AND CORE REMOVED

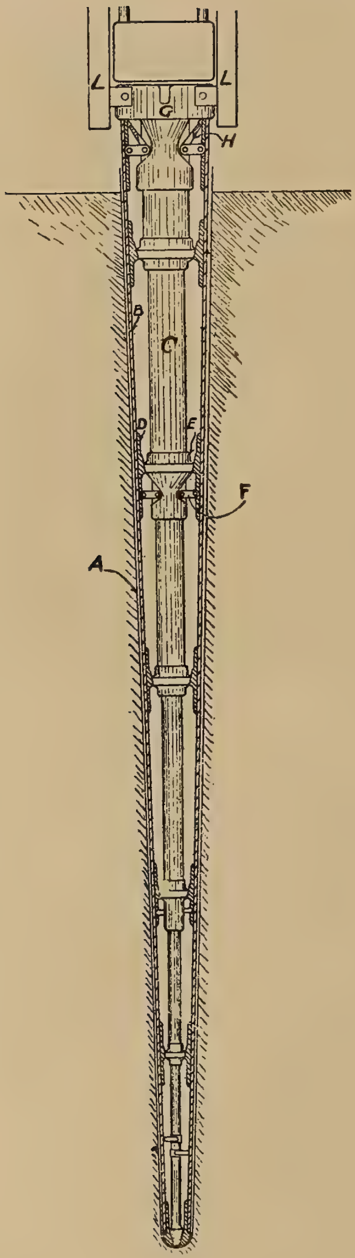
accomplish a recovery of the former penetration and have momentum enabling them to go further. The advantage of the churning process lies probably in the circumstance that the pile, when struck by the weight, possesses a much reduced skin friction. It would seem probable that the original skin friction is not fully recovered when the loosened pile regains its former position, seeing that now it is in motion and not quiescent. However, churning was found to have little or no advantage when really hard driving had to be done. So that when penetration became difficult, the chain would be disconnected and the ordinary procedure of dropping the hammer through a considerable distance adopted. The essentials of the cushion head, which was used as an intermediary between pile and hammer, were an oaken block, with numerous layers of rope and rubber belting secured to its lower end. In the paper of Messrs. Thompson and Fox, in the *Journal Association Engineering Society* (January, 1909), costs are analyzed. They estimate the net cost under Boston conditions of a total of 48 piles, each 30½ feet long, at $1.63 per lineal foot of pile. They found that an increased expertness developed with the progress of the work. So that on a larger job, this would certainly tend to a reduction of cost. Further, there were certain items whose total expense would be the same for larger or smaller jobs. In consequence of these circumstances, the expense of $1.63 per foot is to be regarded as too high for larger jobs and too low for smaller ones.

In further illustration of driving concrete piles by means of a water-jet and without exterior grooves for the return current, we may cite the 5,426 piles driven for the steamship terminals at Brunswick, Ga. These piles were from 30 to 51 feet in length, and were of a uniform and square cross-section of 16 x 16 inches from the head to within about 10

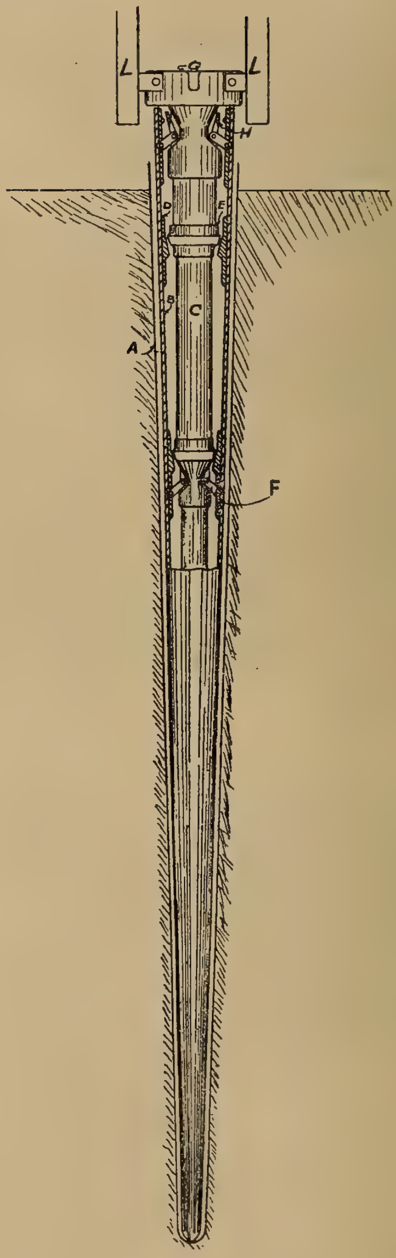


HOISTING A CONCRETE PILE AND HYDRAULIC JET BY PILE DRIVER

HAULING A GILBRETH CORRUGATED PILE INTO POSITION



RAYMOND CONCRETE PILE CASING AND CORE IN PLACE

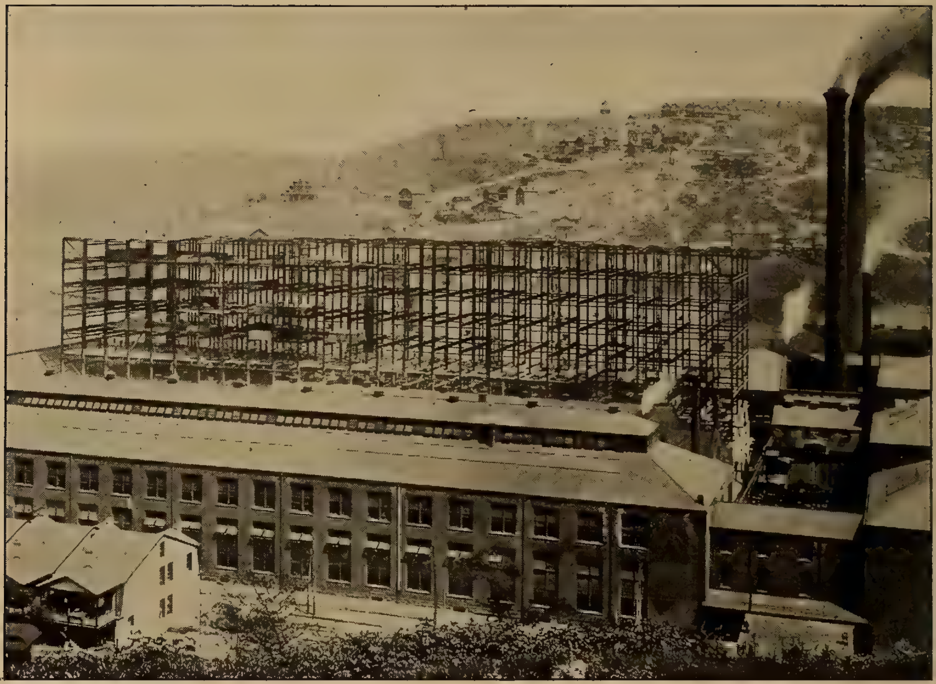


RAYMOND PILE, CORE COLLAPSED FOR WITHDRAWAL

feet of the tip. They were then drawn in to one-half the dimensions. The corners were slightly chamfered. At the head, shoulders were cut in from two opposite sides, so as to form a kind of tenon 8 x 16 inches in section and 16 inches deep. A cast-steel cap, supplied with a rope and rubber cushion, was fitted over this tenon. The hammer weighed

PREPARING CASINGS FOR RAYMOND CONCRETE PILES

4,500 pounds. The water-jet was uniform in diameter to the very tip, so that the velocity was not increased. The first attempts at driving some 51-foot piles through 40 feet of soil were not encouraging. The procedure was by jet and hammer. However, when the method was adopted of raising and dropping the piles themselves, loaded with cap and hammer, results of a very satisfactory character were obtained. The drop was from one and one-half to two feet. As the piles themselves weighed about five tons apiece, the total weight dropped was about seven tons or more. The driving was so facilitated by this mode of procedure that instead of placing four to six a day, it was found possible, at times, to put in position as many as 27 to 30 in fourteen hours, the piles in the latter case ranging from 30 to 51 feet. Of course, without detailed information as to variations in the bottom, it is impossible to make exact comparisons. However, Mr. M. M. Cannon, in his paper presented to the Boston Society of Civil Engineers, seemed to regard the improvement as a notable one. The material through which the driving was effected by the combination of the hydraulic jet with the procedure of dropping both pile and weight ranged from sand to hard clay and soft rock. These piles were reinforced by four 1¼-inch steel rods, bound together by loops of small diameter. There was at the upper end an additional reinforcement of Clinton electric-welded fabric. As the entire pile was not driven into the soil, it was not necessary that the pipe for the jet should extend to the very head. Instead, it was brought to the surface of the pile and terminated at such a point that, when fully driven, the upper end would be at the bottom level of the water. By this means a very considerable saving of pipe was effected. Practically no trouble was experienced with clogging of the



BUILDING OF THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., EAST PITTSBURG, EIGHT STORIES HIGH, SUPPORTED ON 25-FOOT RAYMOND CONCRETE PILES

lower end of the jet pipe when driving.

Neither in the Cambridge case, nor in this one at Brunswick, nor yet in another one at Charleston, S. C., in all of which the hydraulic jet was relied upon, does there seem to have been any provision for a return current of water. It would appear, then, that penetration was effected by compression of the soil. Now in the Gilbreth system, it will be remembered, the external longitudinal grooves provide not only for return of the water but for removal of the soil. In other words, the Gilbreth patented pile and process accomplish penetration by simple excavation.

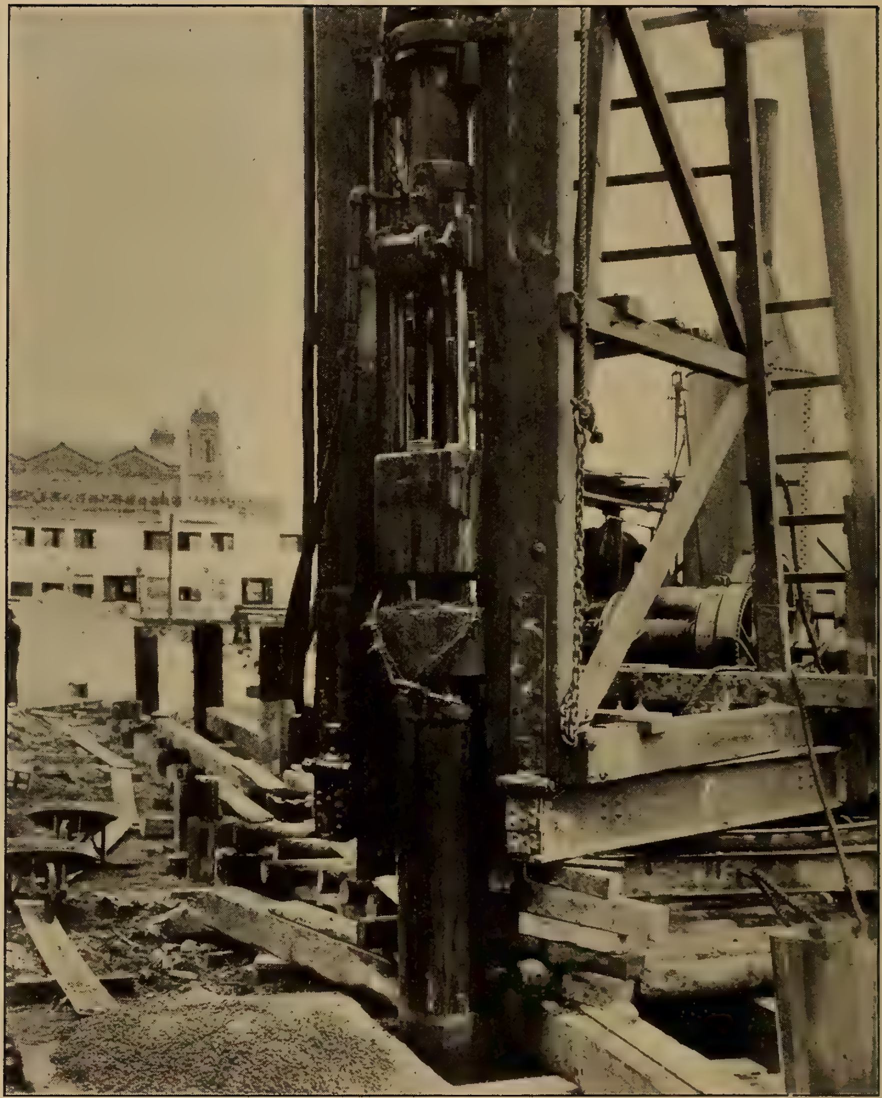
THE RAYMOND PILE.

There seems but little doubt that concrete is a most admirable material for piles. The great question is, however, how best to put it in place. The Simplex pile is formed by pouring concrete into a casing which is concurrently withdrawn; the corrugated pile is cast above ground and then driven into place. With the Raymond pile, the casting is done in place as with the Simplex, but the casing is not removed. It remains in the ground and thus becomes a permanent part of the pile. By this system the shell is so driven that its own stiffness is not depended upon to effect the displacement of the soil. In this respect the Raymond pile differs markedly from the Simplex. The shell of the Raymond pile is quite thin and consists of a series of sections of thin sheets of steel. In fact, it is not at all unlike the common stove-pipe. When being driven, it is filled with a driving core, which gives solidity to the whole. When sufficient penetration has been accomplished, the core is collapsed and withdrawn. The shell, made of 18 to 20 gauge sheeting, while not stout enough to be driven without internal support, is, never-

FOUNDATION OF BUILDING FOR WESTINGHOUSE ELECTRIC & MANUFACTURING CO., EAST PITTSBURG, PA.
RAYMOND CONCRETE PILES

theless, sufficiently stiff to withstand the compressive effect of the surrounding strata upon withdrawal of the core. There is thus formed a hollow mold, into which the concrete is poured to make the pile proper. If there is any doubt as to the condition of this mold, an electric bulb may be let down previous to the pouring of the concrete. Or sunlight may be thrown into the shell by a mirror. If the sheeting has been seriously damaged in driving, or if a local collapse has taken place, the light will disclose it.

An ordinary pile-driver may be used. The core is, however, a special device, so made that when the three segmental parts are in driving position, it is the exact form and volume of the concrete pile desired. This core is itself driven and carries with it the shell. Before operations begin, the sections of the shell



PILE DRIVER SINKING THE CASING FOR RAYMOND CONCRETE PILES

are assembled about this core. The overlap may be made by a lower section over an upper, or the reverse. Each section may be all in one piece, or it may consist of two halves longitudinally separable.

This pile is of a tapering form. This is claimed as a distinct advantage. Unquestionably, it transfers a large part of the mechanical support otherwise supplied by the foot to the sides, where it is associated with the skin friction. The load-carrying capacity of a tapering pile is assisted, also, by any compressive action of the surrounding soil. A tapered Raymond pile, 22½ feet long, was sunk on the site of the new buildings for the U. S. Naval Academy at Annapolis, Md., and subsequently tested by the Government's engineers by weighting with 59½ long tons. Settlement was very slight.

Now, a little consideration will show one that if a pile is driven to a firm footing on rock or in hardpan, it becomes a kind of column loaded at both ends. Here support is mechanical and only a slight taper should be used, as this permits the cross-sections of the two ends to be made nearly equal. But, if skin friction is to be mainly depended upon for supporting capability, then a short pile sharply tapered is recommended. If it seems advisable, the number of piles may be increased. The standard terminal diameters for the short 20-foot piles are 20 and 6 inches. This is a taper, relatively to the axis, of 7 to 240 or 1 to 34.3. For a 30-foot pile, the standard taper is 6 to 360 or 1 to 60. Although the heads of both sizes are 20 inches in diameter, 60 lineal feet of the more sharply tapered style are said to have a greater load capacity than 60 feet of the more gently tapered form. That is to say, three standard 20-foot piles will support a greater load than two 30-foot ones.

With reference to the comparative load capacities of tapered and cylindrical piles, the case of two piles, driven on the site of the Naval Academy and close together, have been cited by Mr. W. R. Harper. A 20-foot Raymond tapered pile was driven 19 feet into the ground, when the penetration, due to two blows from a 2,100-pound hammer falling 20 feet, was found to be but ⅞ inch. Another pile of wood, and approximately cylindrical, was found to penetrate 5 5-16 inches, when approximately 19 feet were in the ground and the hammer blows were precisely the same. The ordinary pile had a diameter at the foot of 9.5 inches, and at the head of 11 inches. The Raymond pile was 6 inches in diameter at the foot and 19.3 inches at a point one foot below the head. Apparently these were thought to be

NEST OF RAYMOND CONCRETE PILES FOR PIER OF THE CUYAHOGA VIADUCT, NEAR CLEVELAND, OHIO

TRENCH SHOWING RAYMOND CONCRETE PILES IN THE FOUNDATION OF THE CRUDEN-MARTIN BUILDING, ST. LOUIS, MO.

equal piles, so that the difference in bearing capacity would represent the advantage of the taper. It is difficult to see how this thought, if it was entertained, could be justified. If we compare the volumes of the two 19-foot piles, we find that the tapered one exceeded the other by about 65 per cent. It is very true that the final penetrations have a much larger inverse ratio than 165 to 100, that ratio being in fact 85 to 14, or 607 to 100. But this does not seem a desirable way to determine the relative load capacities. If we consider, not the volumes but the lateral surfaces, we find a closer approach to equality, the ratio between the Raymond surface and that of the wooden cylindrical pile being 253 to 205. It seems, despite the fact that the two piles were in no sense upon an equality, that the great superiority of the tapered surface is to

be ascribed largely to its conical form. It would seem advisable, however, that there should be made a comparison of the load capacities of two piles having precisely the same cubic contents and differing only in one being a cylinder and the other a cone. It would appear that the evidence is in favor of the superiority of the tapered pile, considered as a load carrier. But a question of this importance ought to be thoroughly tried out and definitely answered.

Of course, this style of concrete piling is readily reinforced by placing longitudinal rods in position before the casting operation. Some method of holding these in place should be employed. If desired, the entire reinforcement may be fabricated above ground. There will then be no difficulty experienced in using heavy wire to bind the longitudinal rods together.

An interesting discovery was made in testing a 22½-foot Raymond pile at Annapolis. This pile had a diameter of 16 inches at the head and 6 inches at the foot. The core and shell were driven until the penetration was reduced to 1 inch for eight blows of a No. 2 Vulcan steam hammer. The shell was filled with a 1-3-7 concrete and allowed to stand for 13 days. It was then loaded with 21 tons. The load was continued and increased at intervals. After the lapse of a number of weeks the final amount was 66½ tons. After this load had remained in place for some time, it was removed. The total amount of settlement increased, from time to time, until it reached a stationary point. But, subsequently to the removal of the final load, the pile actually rose .108 inch. However, this phenomenon seems to have occurred with other piles elsewhere, and so can hardly be ascribed as necessarily a consequence of the taper. It would seem, however, that in a constrictive soil a tapering pile should experience some degree of upward thrust. This would, of course, assist its load-carrying capacity. This upward pressure can, however, scarcely be considerable in amount.

It is interesting to know in detail how in the Raymond system the driving core is constructed and operated. There are three heavy plates, which together form the exterior surface of the hollow core. Longitudinal spaces separate these segments when driving is in progress. (See illustrations page 508.) These spaces permit contraction when it is desired to withdraw the core. In the first illustration on that page *C* represents a series of pipes connected by steel castings, *E*. These castings have a conical zone, which contacts with the interiorly conical surfaces of another set of castings, *D*. These latter castings are secured to the segmental driving shell. It will be seen that a downward thrust of the central line of piping will have the effect of expanding the segments. To this expansion the links, *F*, set a limit. Driving of the whole is accomplished by striking the head *G* by the hammer of the pile-driver. A wooden block is arranged in this head and receives the blows. In the second illustration the driving core is seen collapsed, ready for withdrawal. The skin friction between the soil and the outer shell, *A*, is sufficient to retain this shell, when the tubing, *C*, is drawn upwards to effect the collapse of the core.

THE STABILITY OF FLOATING DOCKS

By Bernard C. Laws, M. I. N. A.

THE stability of a floating dock has to be considered when floating alone under its own weight as well as with the vessel for the docking of which it is designed resting on the blocks.

In what follows it is proposed to consider generally three types of this class of floating body. The underlying principles are identical with those relating to floating bodies in general, but it will be seen that problems of a somewhat different nature to those met with in ordinary vessels are involved.

A general view, showing a vessel docked, is given in Fig. 1 for a double-walled dock, Fig. 2 for the L or offshore dock.

The points of difference to be considered in the stability of floating docks as compared with that of an ordinary ship-shaped vessel may be summarized as follows:

1. The water-plane area and the moment of inertia of same necessarily vary very considerably between the deep draft at which the vessel takes the blocks and the least draft at which the dock ultimately floats, and with this must be considered the effect of the variation of water-plane area of the ship as the latter gradually becomes emerged.

2. The internal compartments of the dock contain water free to move as the dock inclines from the upright, the effect being prejudicial to the good stability value of the dock. With a ship such free bodies are assumed non-existent when stability calculations are made, *i.e.*, the water ballast compartments are either assumed to be full or empty.

3. The effect of wind pressure may be such that in the case of a ship free to move considerable heeling will result. With the dock *practically* no heeling is permissible, as any tendency to heel after the vessel had taken the blocks would bring undesirable straining action on the shores and supports, with possible disastrous consequences.

It is, therefore, necessary in the ordinary case to consider only *small* angles of heel, up to one or one and a half degrees, and the calculations must be considered at intervals from the deep to the minimum floating draft.

The case of the double-walled or U-dock presents the simplest problem, for the obvious reason that the structure is symmetrical about a centre longitudinal plane, and floats practically free from constraint. The metacentric method, *i.e.*, the consideration of the relative positions of G (centre of gravity) and M (metacentre) is usually sufficient except where the dock may be required to be transferred across seas to its ultimate destination, or where careening for repairs or painting is a condition of the design, when a further calculation for statical stability would be made.

Fig. 4 shows the metacentric curves for the case of a double-walled dock of skeleton dimensions indicated in Fig. 3, the dock having a maximum length of 350 feet, and the walls an effective length of 300 feet.

Of the curves shown:

A refers to dock only,
B " " vessel only,
C " " system (*i.e.*, dock and vessel).

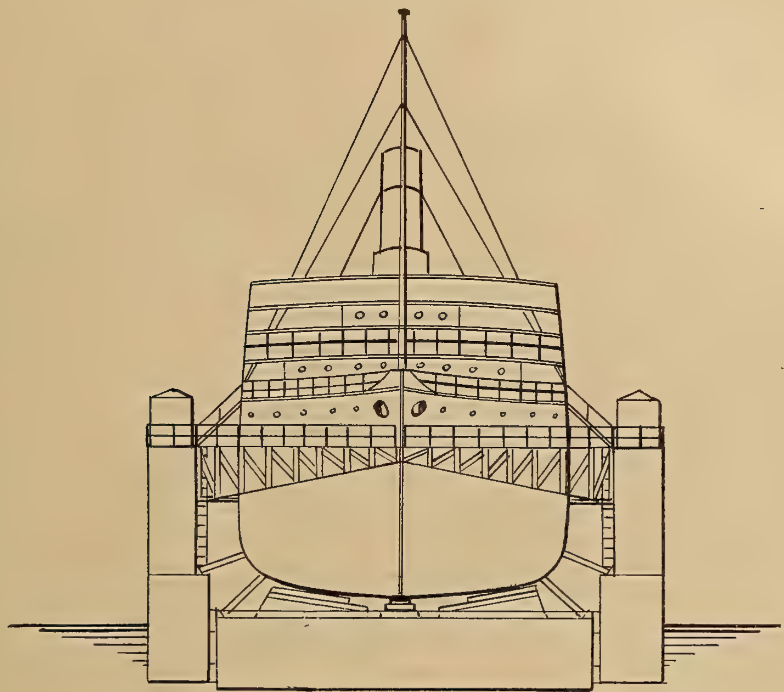


FIG. 1.—SHOWING BOAT DOCKED IN DOUBLE-WALLED DOCK

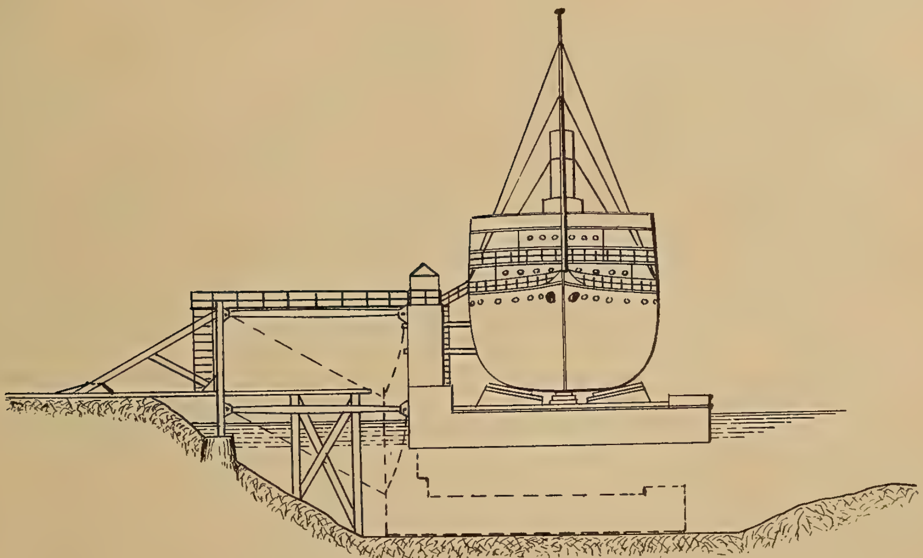


FIG. 2.—DIAGRAM OF A BOAT DOCKED IN L-SHAPED DOCK.

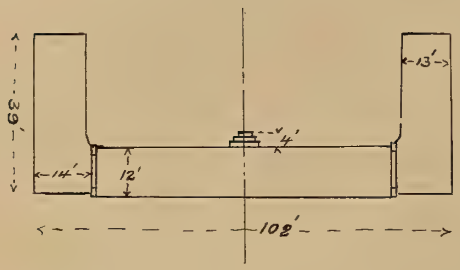


FIG. 3.—SKELETON DIAGRAM OF DOUBLE-WALLED DOCK

They are plotted to a scale of "height of metacentre" in feet above bottom of dock, so that at any draft a horizontal line drawn to cut the curve gives the height of metacentre at that draft above the dock bottom, as, *e. g.*, *A O* at the 16-foot draft mark.

The dimensions of the vessel to which the curves *B* and *C* refer are 350′ 0″ x 43′ 0″ x 28′ 0″ by 28′ 6″ mean draft.

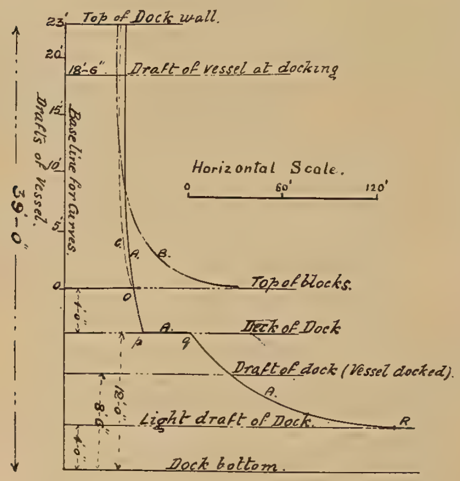


FIG. 4.—METACENTRIC CURVES FOR A DOUBLE-WALLED DOCK

Analyzing this diagram the effect of the vessel in modifying the dock metacentric curve *A* and producing the resultant curve *C* will be clearly seen. At *O*—the top of blocks—the curve for system joins the curve for dock only, and for drafts less than 16.0 feet they are identical.

The period from *O* to *P*, during which the dock emerges from the draft 16 feet to 12 feet, at which latter the deck of the dock becomes awash, has been termed the *critical* period and the curve suddenly breaks away horizontally from *p to q*, due to the sudden increase of moment of inertia of water-plane area from that of the section of the walls and blocks (or in the case of the L dock—of wall air box and blocks) to that of the full section of the walls and pontoon together; the curve further falls away to *r* at the minimum docking draft.

The position of the centre of gravity will naturally vary with the draft, due to letting in or pumping out the water ballast from the compartments. Knowing the position for any particular draft the metacentric height or initial stability of the system may be at once obtained.

It is usual to assume for purposes of calculation that the ship has no metacentric height, and in consequence the stability value of the system is enhanced.

Not infrequently has a steamer only a few inches of initial stability and, in some cases, the latter might have even a negative value just previous to docking, when the vessel would be brought into the upright by ballasting before being placed on the blocks.

The case of the single-walled or L-dock is treated somewhat differently to that of the double-walled type referred to above, and of the two L types, *viz.*, the offshore and the outrigger docks, we will consider each in the order stated.

The dock proper is attached by booms, in the one case to land ties, and in the other to a floating pontoon, the booms working on pins at their extremities, thus giving freedom of action as the draft of the dock changes.

It is readily realized how important a part the booms play in establishing the safety of the system. Fig. 5 is a diagrammatic representation of an offshore dock floating in such a position of equilibrium that *B* (centre

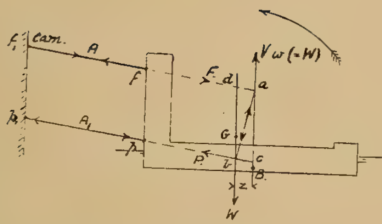


FIG. 5.—FORCES ACTING ON L-SHAPED DOCK WHEN FLOATING

of buoyancy) and G (centre of gravity) are as indicated.

In the position shown there is a tendency to rotation in anti-clockwise direction about some axis. This tendency, measured by the product $W \times Z$, is counteracted by the action of the booms A and A_1 in the two tiers, so that if F and P be the forces called into play in the respective tiers it is clear that for equilibrium F must be equal to P; of these stresses F is compressive and P tensile; and the greater the value of the product W x Z or of Z for a given value of W the greater will be that of F and P.

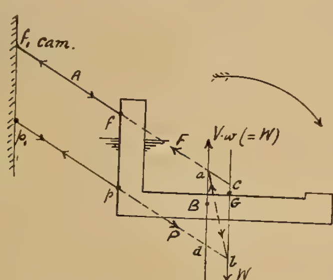


FIG. 6.—FORCES ACTING ON AN L-SHAPED DOCK WHEN IT IS BEING IMMERSED

Obviously, then, to reduce the straining action on the booms to a minimum, Z should be small, and may be brought about by so disposing the water ballast as to bring B and G practically into the same vertical (longitudinal) plane, or perhaps with G situated a little nearer the wall of the dock than B, so as to obtain a couple $(W \times Z)$, tending to give the dock a slight tilt backward, at the same time supplying an element of safety in docking by compelling the vessel to lie inwards.

The inner end of the upper tier boom is pinned to a cam working on a centre as at f_1, the cam being so weighted that a limited freedom of motion of the boom end is permitted and with it the dock itself.

By increasing the immersion the centre of buoyancy B moves inwards towards the wall of the dock and the conditions may be such that the

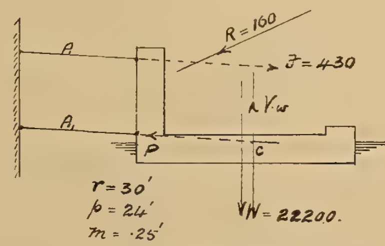


FIG. 7.—ACTION OF WIND PRESSURE ON L-SHAPED DOCK

couple $W \times Z$ will tend to produce angular displacement in the clockwise direction as indicated in Fig. 6, when the nature of the stresses in the booms will be reversed so that now A experiences tension and A_1 compression.

The booms being pin jointed at the ends will experience no direct bending action, but will generally be subject to compressive or tensile stresses in the manner already stated. Upon the allowed maximum value of these stresses the design of the

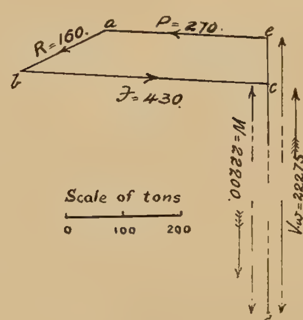


FIG. 8.—FUNICULAR POLYGON OF FORCES ACTING ON L-SHAPED DOCK

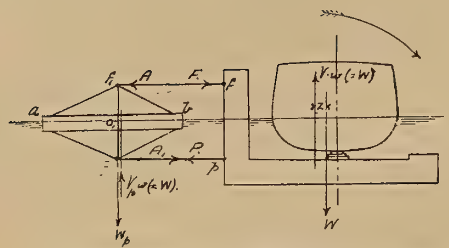


FIG. 9.—L-SHAPED DOCK WITH PONTOON OR OUTRIGGER

booms will depend. If U be the vertical distance ($=fp$) between the tiers, e the angle which the booms make with the horizontal at any time, and N the number of booms in either tier, then: $F_1 = \dfrac{W \times Z}{N\,U\,Cos\,e}$ is an equation giving the straining action on the booms.

If at any time the conditions are such that from some cause or other bending of the booms takes place or tends to take place, so that the line of action of the direct stresses mentioned above does not coincide with the axis of the boom, then the strength calculation of the boom would be modified accordingly.

Suppose now a force R—say due to wind pressure—be introduced, disturbing the equilibrium of the system. If R is more than transient the system will settle down into a new state of equilibrium in which the following conditions would be experienced, see Fig. 7.

F and P will not now be of equal value, nor will $V \times w$ (weight of water displaced) be equal to W (weight of dock or system). If c be the point of intersection of the line of action of P and $V \times w$ and r, p, and m be the perpendicular distances of c from the lines of action of R, F and W respectively, then for equilibrium we have

$$F = \frac{R \times r + W \times m}{p}$$

the other forces, *viz.*, P and $V \times w$, could be similarly obtained, but it is more instructive to draw the funicular polygon of forces, as shown in Fig. 8, in which the values of R and W are assumed 160 and 22,200 tons respectively. In this way the values of P ($= ea$) and $V \times w$ ($= de$) under the new conditions may be obtained.

If now R, after acting for a period, be suddenly withdrawn, or, as is usually the case, it be of a transient nature, then since $V \times w$ is $> W$ oscillation in a more or less vertical direction will be set up, the period of which may be obtained from the

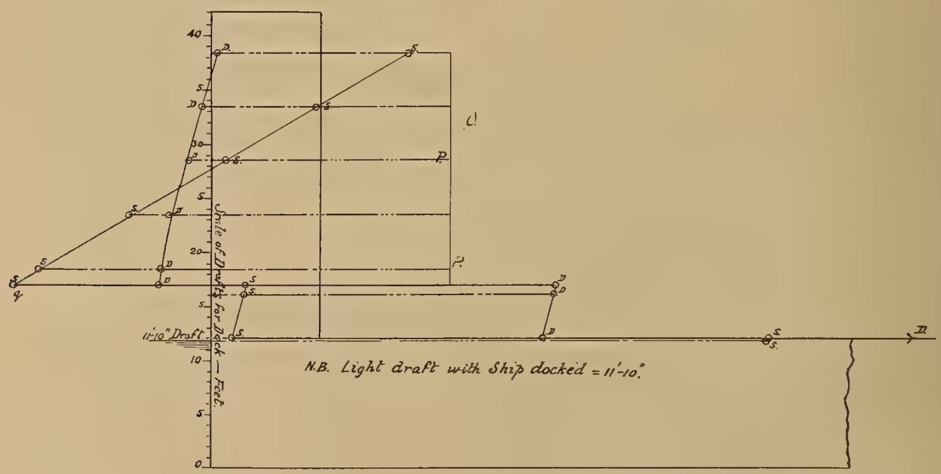


FIG. 10.—DIAGRAM OF STATICAL STABILITY FOR ANGULAR DISPLACEMENT OF 1 DEGREE. CURVE "S," DOCK AND SHIP; CURVE "D," DOCK ONLY; CURVE "P," PONTOON (OUTRIGGER).

formula: $\dfrac{d^2 z}{dt^2} = -\dfrac{w \times A \times g}{W} \times Z$
the limits of amplitude of vibration z being $\pm \dfrac{V \times w - W}{w \times A}$ where A is area of water plane and z the increase of draft.

Since $V \times w$ is now greater than before R acted, the stability value of the dock will be slightly modified. R may be taken at 30 pounds per square foot of normal surface exposed.

In determining the conditions for stable equilibrium note has to be made that the water-plane area is broken, being composed of the horizontal section of the ship, dock wall, etc., in consequence of which the centre of gravity of water-plane area takes up an irregular position, varying with the draft, and the moment of inertia of water-plane area will now be taken about an axis through that centre of gravity.

For a small angle of inclination Θ the statical stability is given by the formula:

$$\left(\frac{I_s - \Sigma I}{V} - B\,G \right) W : \Theta \ldots\ldots \mathrm{I}$$

where I_s is the moment of inertia above referred to and I is the moment of inertia of free water surface in any one compartment relative to an axis through its centre of area.

If the dock only were considered I_s would be replaced by I_d where I_d is the moment of inertia of water-plane area referred to dock only.

In Fig. 10 curves—"*D*" and "*S*"—of statical stability for one degree of inclination are shown and relate to a dock of dimensions indicated in Fig. 11 and referred to hereafter.

Taking now the case of the outrigger type of dock—see Fig. 9—equilibrium is maintained by virtue of the joint action of the booms A and A_1, the sustaining forces acting along them being supplied by the stability or righting power of the pontoon a b, which latter generally

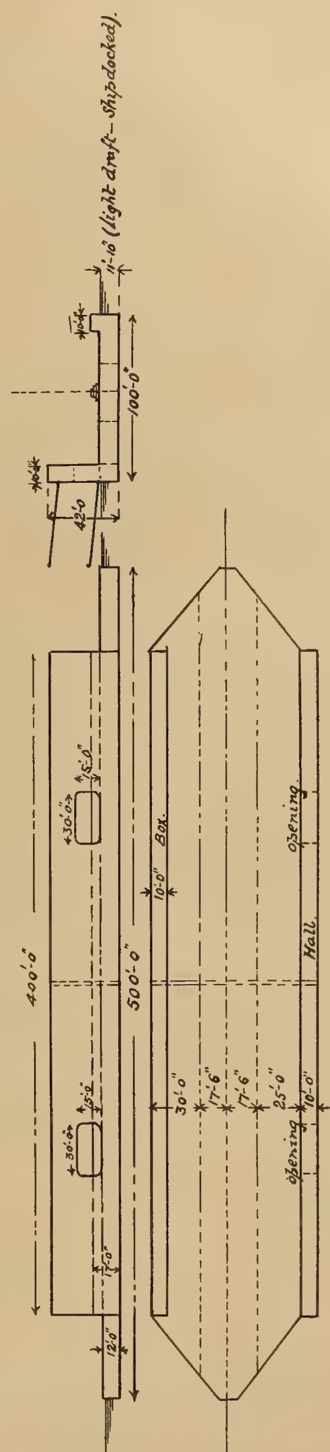


FIG. 11.—ELEVATION, PLAN AND SECTION OF SINGLE-WALLED OR L-SHAPED DOCK

floats immersed to about its half depth, the position being invariably one of perpendicularity to the dock wall, since the booms have a parallelogram motion and work on *fixed* centres as f f_1, p and p_1.

If a tendency to angular displacement take place in, say, the direction indicated in Fig. 9, the forces F and P called into play will be a direct consequence of the stability value of the pontoon a b, hence the upsetting tendency of the dock must not exceed, and for safety not approach, this value.

The stability of the system, therefore, is always the algebraic sum of the stability values of the pontoon and dock.

The expression for the pontoon in fresh water is:

$$\frac{I_p \times \Theta}{36} \text{ nearly} \ldots\ldots\ldots \text{II}$$

Assuming that there is an absence of free water and that B and G are practically coincident.

The algebraic sum of the expressions I and II gives the stability value of the system and the curve of statical stability for the pontoon will give the maximum couple beyond which the upsetting moment of the dock may not go for safety.

Such a curve *"P"* is shown in Fig. 10 for an angle of heel of one degree and relates to the pontoon of dimensions $320' \times 70' \times 5' \times 2.5'$ draft designed, to work the dock outlined in Fig. 11, this latter being designed to lift a vessel of about 11,000 tons displacement.

The above-mentioned curve is, of course, a straight line parallel to the line of abscissæ and the algebraic sum of the ordinate values of this line and that of *"D"* or *"S"* at any draft gives the statical stability of the system at that particular draft.

Inspecting these curves it will be noticed that the stability both of the system (dock and vessel) and the dock only is negative for a portion of the time during which immersion takes place, *i.e.*: For the system, between the drafts, 28 feet and 17 feet; for the dock only, between the drafts, 36 feet and 17 feet; but the positive stability value of the pontoon as expressed by the curve P is always sufficient to counterbalance this and ensure safety to the system.

The question of longitudinal stability would be treated in a manner similar to the foregoing, and it is, therefore, unnecessary to deal further with the subject here, beyond the statement that there is ample stability in the longitudinal direction, which is further assisted by the steadying action of the booms in the case of the L-dock and the moorings in the case of the double-walled dock.

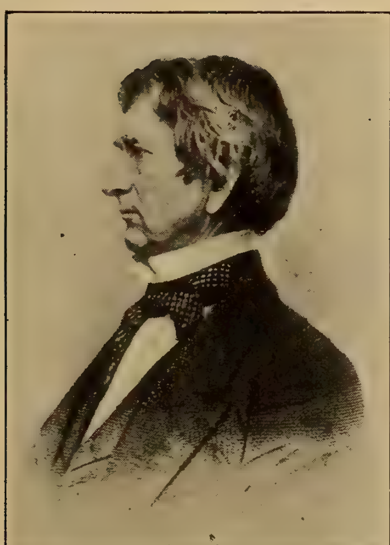
There are several other points relating to this subject and to the geometry of motion of floating docks which are at once instructive and interesting, but their consideration would, perhaps, be beyond the scope of the present article.

ALASKA

ITS WEALTH OF NATURAL RESOURCES AND COMMERCIAL POSSIBILITIES

By A. J. Quigley, Assistant Electrical Engineer, Alaska-Yukon-Pacific Exposition

AUTHOR'S NOTE.—The following discussion is aimed to cover as comprehensively as may be a very large subject within the narrow confines of a few pages, and the result, of necessity, is summarization rather than detail information. Facts presented are derived from the exhibits at the Alaska-Yukon-Pacific Exposition, from latest published reports, and from experts whose knowledge is based on years of experience, and are as accurate as the rapidly-changing conditions will permit. The object has been to answer the question: "What are the resources, developed and undeveloped, of Alaska?" The line of discussion treats of Alaska's early history, its purchase by the United States, its connection with the Alaska-Yukon-Pacific Exposition, and its present industrial condition, with special thought as to the probable development during the next decade and the more distant future.



WILLIAM H. SEWARD, THE MAN RESPONSIBLE FOR THE PURCHASE OF ALASKA IN 1867

IN spite of the onward rush of Twentieth Century progress, the world is to-day pausing to look herself over; to take stock of what she has left to offer to future generations. Ex-President Roosevelt is largely responsible for that very sane condition of affairs, for his recent Conservation Congress set this world, and, more especially, this careless America, to thinking. The pessimist could see only the mistakes of the past, but, through the hue and cry that arose because of lost opportunities and of wanton waste, there has come the stronger call of the optimist, who cheerfully considers the past useful only as object lessons for the future, and, hopefully looking forward into that future, sees new lands teeming with potential possibilities such as our forefathers never dared dream of. Many portions of the world are as yet comparatively little known, and each can justly lay claim to wonderful undeveloped resources, but none can make more striking claims than the erstwhile "Russian White Elephant." Alaska is now recognized as the treasurehouse and the wonderland of America.

EARLY HISTORY

The early history of Alaska in a measure duplicates the present-day story, since nature has ever seemed determined to baffle the encroachments of man's prying eyes and to keep securely locked the wonderful secrets of this Northland. The battle lasted over one hundred and fifty years before man scored a decisive victory, and loyal Americans may indeed be proud that a wise statesmanship placed the Stars and Stripes over Alaska before that one hundred and fifty years had rolled by.

In 1793 an expedition was out-

fitted by Peter the Great, of Russia, and placed in charge of the Dutch navigator, Vitus Bering. Two ships were provided, the St. Peter and St. Paul. The materials which entered into the vessels were transported from Russia across the Siberian wastes, a distance of several thousand vestas. These materials were forwarded in detachments, and it was not until eight years later that the ships were ready to set forth on that important and historic cruise. Soon after the start the ships became separated in the fogs and never again saw each other. The St. Peter, commanded by Bering, sighted what is now Alaska on July 16, 1741, the land sighted probably being Mt. St. Elias. From the records it would seem that the real discovery was made two days earlier by the sister ship, St. Paul, under command of Lieutenant Alexel Chirikoff, when she came to anchor off of what is now Cape Coddington. The story of the subsequent hardships and of loss of men and ships cannot be told here. The new land was discovered in 1841, and this in brief was the manner in which Russia gained title to that domain.

THE ALASKA EXHIBITION BUILDING AT THE ALASKA-YUKON-PACIFIC EXPOSITION

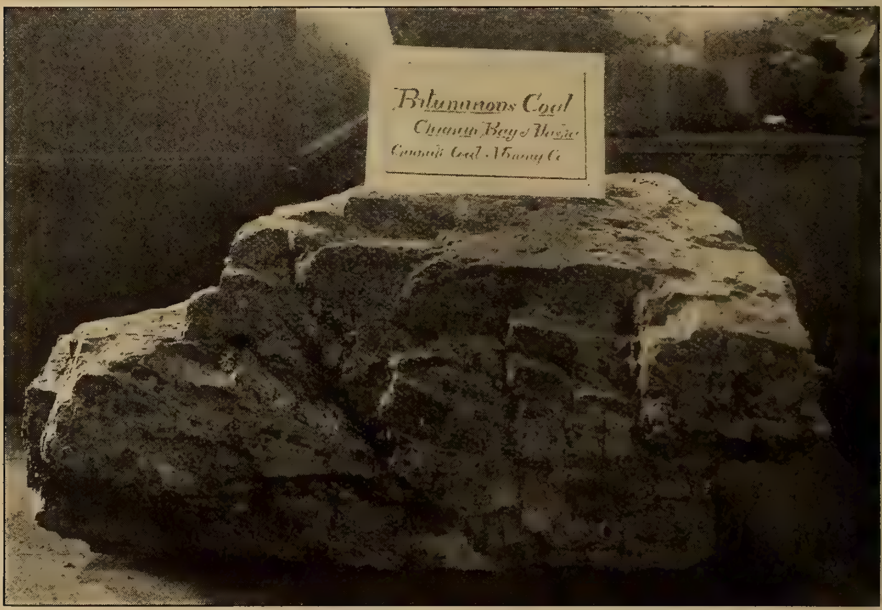
PURCHASE BY THE UNITED STATES

After the Civil War the Secretary of State, Hon. Wm. H. Seward, set out to purchase Alaska from Russia, and at once brought about his head a storm of protest from an indignant public. The press and cartoonist made merry with the idea as being "Seward's Ice Box," "The White Elephant," and "Seward's Folly." When finally the purchase was made in 1867, in spite of this widespread opposition, the people tried to console themselves with the thought that the $7,200,000 was sort of a gift to Russia as a mark of appreciation for her friendship during the Civil War. That Alaska could ever be of any particular use to the United States never occurred to the rank and file. Seward, however, was a seer who was a generation ahead of the times. Ten years

THE ALASKA GOLD BOOTH, CONTAINING $1,250,000 IN GOLD
At night the table automatically disappears and is locked into a concrete vault located below the cage.

THE MARBLE BOOTH AT THE EXPOSITION, MADE OF ALASKAN MARBLE

ago a few people awoke to the fact that Alaska contained something besides snow and ice. During the last decade the ever-widening stream of gold that has flowed southward from that land has taught people that vast wealth is surely there, and to-day a great exposition is endeavoring to teach the world the real significance of the "White Elephant" purchase of forty-two years ago.



SAMPLES OF ALASKAN COAL ON EXHIBIT AT THE ALASKA-YUKON-PACIFIC EXPOSITION

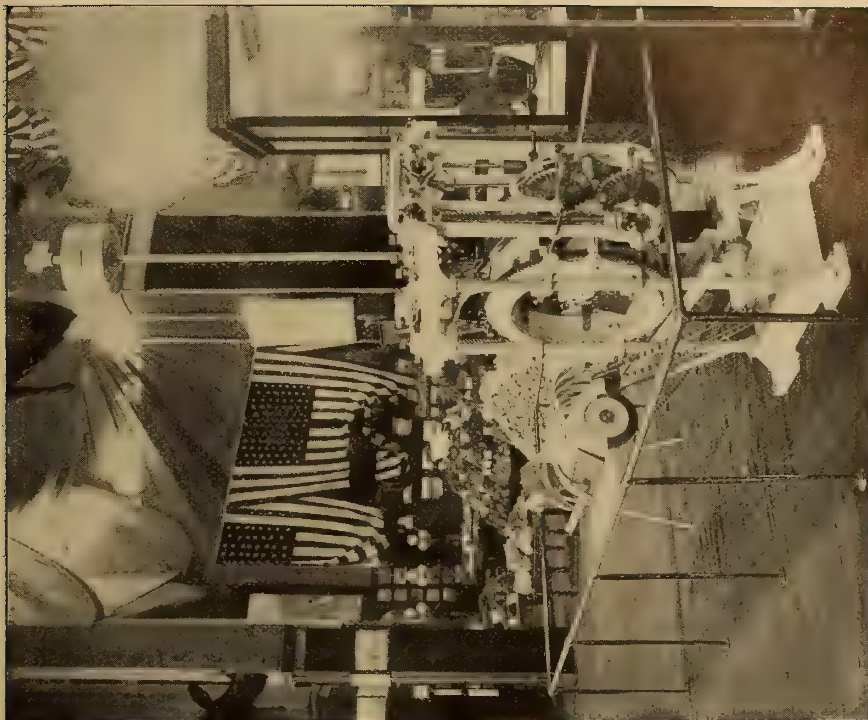
ALASKA AT THE ALASKA-YUKON-PACIFIC EXPOSITION

Alaska is really responsible for the being of the Alaska-Yukon-Pacific Exposition, and for that reason her name comes first in the triple title. In 1905, Godfrey Chelander, a business man of Skagway, was sent by the Governor of Alaska as a special agent from Alaska to the Lewis and Clark Exposition at Portland. The limited time available for preparation gave Alaska an entirely inadequate representation, much to the disappointment of Mr. Chelander. To set this mistake right he soon advanced the idea of later holding a purely Alaskan fair at Seattle of such size as to be housed in one building, and to cost $100,000. This was the start of the Alaskan-Yukon-Pacific Exposition enterprise. As the plan took definite shape it grew at a rapid rate, until it included the Yukon Territory, the great Northwest, and finally, the Pacific countries. Such in brief is the story of how to-day Seattle is holding under nearly a hundred roofs a $10,000,000 exposition with Alaska as a central feature.

To provide for Alaska's exhibit, the government erected a handsome building containing 36,000 square feet of floor space and made an appropriation of $100,000 to provide exhibits which should show Alaska in its true light to the visiting throngs. Thus the fair is a great educator and will do more to give the public correct ideas regarding Alaska than could an equal expenditure in any other way.

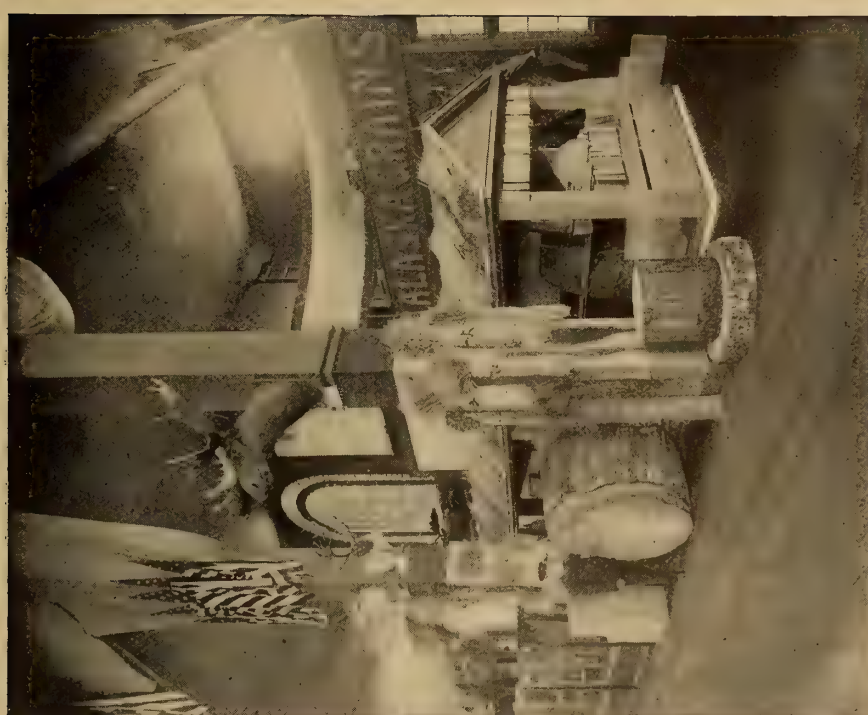
The exhibits are carefully grouped under seven heads, namely:

Agriculture, Horticulture and Forestry.



THE IRON CHINK

A machine that cleans completely salmon and other fish at the rate of fifty per minute. It handles any size from two to twenty pounds.



A SECTION OF THE ALASKA EXHIBIT AT THE ALASKA-YUKON-PACIFIC EXPOSITION, SHOWING ALASKA GRAINS

TYPE OF NATIVE ESKIMO

Furs, Animals and Birds.
Fish and Fisheries.
Mines and Minerals.
Transportation.
Ethnology and Native Work.
Schools, Women's Work and Art.

Each division shows such progress and development as to be astounding to those unfamiliar with real conditions.

In connection with the exposition several exhibits require special notice. Easily the most notable exhibit is the gold booth cage standing in the center of the building and containing behind its iron bars and glass sides, gold dust, gold bricks, and great gold nuggets to a total value of $1,250,000—truly a spectacular way of impressing upon the mind of the visitor the lesson of Alaskan gold. In the fisheries division stands a machine that means much to the development of Alaska. It bears the title "The Iron Chink," is the invention of a Seattle man, and has such mechanism that one machine will clean completely more fish than could a small army working by hand, and do it better too. As a frieze about the entire room is a series of large paintings—true depictations of Alaskan scenes and scenery. In a separate room at the rear of the building is produced an elaborate panoramic view of Alaskan life, activities and scenery, so arranged that the wonderful sunlight and moonlight colorings and shades of the Northland are electrically obtained with peculiar beauty. On the "Pay Streak," the amusement center of the exposition, one finds within the walls of the Eskimo village a splendid exhibition of the native life of Alaska, while at an opposite corner of the grounds stands the home of the Arctic Brotherhood, an organization composed only of those who have held residence in Alaska. Each of these and other exhibits is doing its work in giving correct ideas of Alaskan life.

ALASKA TO-DAY

Population and Climate: Passing from the Exposition Alaska to the real Alaska new wonders are in store. It has officially been called a district. It is not. Instead it is an empire, containing 584,600 square miles (equal to one-fifth the area of the entire United States), having a shore line of 26,800 miles (greater than the circumference of the earth), and a diversity of resource and climate that presages a future commercial greatness. If superimposed upon the United States Alaska would

CHIEF "SCHWATKA," OLDEST INDIAN GUIDE IN ALASKA

extend from coast to coast and from Canada on the north to Mexico on the south. The general topography is that of a great plateau valley extending east and west across Alaska and hemmed in by two coast ranges, the northern extremity of the Rockies on the Arctic Ocean side, and, on the south side, the Pacific Coast Range, extending far out into the ocean on the Aleutian Islands. Draining this great area are many rivers, the principal of which are the Yukon and the Kuskokwim, the former the fifth largest in the United States. Within the vast area of Alaska a mere handful of people find homes, the census for 1900 giving a total of 63,592, of whom 30,507 were whites. The present white population is estimated at not more than 40,000, or about one person to every fifteen square miles. An estimate of present distribution of white population is as follows:

Ketchikan	1,200
Wrangel	400
Juneau	2,000
Douglass } Treadwell }	3,000
Skagway	1,000
Cordova	2,000
Valdez	1,000
Seward	200
Fairbanks	3 500
Nome	3,000
Sitka	400
Scattering	22,300
Total white population	40,000

The range of climatic conditions is remarkable and yet, after all, is more equitable and delightful than a majority of people imagine. Figures taken from the United States Weather Bureau records are of special interest in this regard:

Analyzing the above table, it will be seen that Alaska has two climatic belts, which may be designated as "the coast region" and the "interior," by which latter term is meant the region north of the coast range. In the coast region the climate is moist and mild in winter, and comparatively cold in summer. In the interior the climate is dry, with a comparatively warm and short summer and long and severe winter. In the coast belt the rainfall is heaviest in Southeastern Alaska and decreases gradually as we pass westward to the Aleutian Islands. At Sitka, the mean annual temperature is forty-three degrees, or almost the same as that of Washington, D. C. The winter temperature seldom falls to zero, and in summer it frequently does not go above seventy on the warmest days. The rainfall in this belt is heavy, because the moisture-laden winds from the ocean are chilled when they strike the coast range and a fall in temperature causes a precipitation of the moisture. For the same reason the region inside the coast range is comparatively dry. The winds have lost their moisture in their passage over the mountains. In the interior belt the summers are short and warm. The thermometer will frequently rise to ninety and ninety-six degrees and even above on the warmest days, but in winter, on the other hand, it will fall to sixty degrees, and even seventy degress, below zero. The short, warm summer, with an abundance of daylight, produces a

WEATHER CONDITIONS OF ALASKA.

Location.	Approximate Latitude.	Annual Precipitation.	Annual Snowfall.	Number Stormy Days.	Lowest Temperature.	Highest Temperature.	Average Temperature Three Summer Months.	Average Temperature Three Winter Months.	Average Minimum for Summer.	Average Minimum for Winter.
Sitka	57°	84.84	36.2	208	— 4	87	54	30	46	30
Kenai	61°	19.40	51.6	97	—46	87	52	20	49	10
Copper Center	62	17.71	87.6	89	—45	90	55	10	38	0
Rampart	65° 30′	11.76	51.4	92	—68	..	58	—14	48	—28
Fairbanks	65	12.60	50.8	91	—65	..	52	—13	37	—25
Skagway	59	29.32	110.5	127	—22	82	55	25	48	20
Nome	64.5	16.13	71.5	91	—32	78	50	0	43	—10
Pt. Barrow	71.5	6.63	12.9	81	—53	65	37	—16	33	—21
Fort Yukon	66.4	10.97	45.6	75	—68	..	58	—23	47	—30

Compiled from maps published by the United States Weather Bureau.

COMPARATIVE SIZES OF ALASKA AND THE UNITED STATES. ALASKA HAS ONE-FIFTH THE AREA OF THE LATTER

rapid growth of every kind of vegetable, and thus it is also possible to mature such grains as barley, rye and oats. Being well to the north, Alaska has the distinctive charm of northern conditions, which, among other things, gives us the midnight sun. The following gives the longest day from sunrise to sunset at various points:

City.	Approximate Latitude.	Length of Day.
Sitka	57°	18 hrs.
Kenai	61°	18 hrs. 35 min.
Fairbanks	65°	21 hrs. 9 min.
Ft. Yukon*	66° 30′	24 hrs.
Pt. Barrow	71° 23′	78 days

* Nearly on Arctic Circle.

Resources of Alaska: Under these conditions of population and climate, what is Alaska doing to-day? In cash values she is exporting in round figures just twice as much as she is importing from the United States, the exports being approximately $1,000 for every white person in Alaska, or nearly $32,000,000 for the year ending June 30, 1908. The last report, by Governor Hogatt, gives detail as follows:

Gold	$20,828,115
Canned salmon	8,125,951
All other fish	800,165
Copper ore	474,172
Whalebone	138,989
Furs and skins	463,108
Silver	20,132
All other products	915,412
Total	31,766,044

The principal resources of Alaska, as at present known, are briefly treated in the following several paragraphs. In many instances the information extant is very meagre, and only future years can unfold the secrets which mother earth now holds securely locked in her bosom:

Gold: Of paramount importance is this product. During the last few years it has averaged nearly $20,000,000 per year, which has given a total since 1880 of over $142,000,000. Up to 1892 the product was always less than $1,000,000. After that date the product gradually rose from slightly over $1,000,000 to $9,160,000 in 1904. In 1908 it amounted to $19,100,000. Most of the gold of Alaska, therefore, has come out since 1898, when the metal was discovered on Anvil Creek in the Nome section, shortly after the great Klondike strike. Behind the barrier of this vast wealth are hidden stories of failure and success—of blasted hopes and poverty, and of good fortune and plenty. The work as carried on by the prospectors by hand is necessarily slow and wasteful, so that improved methods will bring into the field districts at present unprofitable, thereby greatly augmenting

the yearly output of the country.

Mining methods of to-day run through the entire scale of efficiency, from the crudest hand rockers to the most complete dredging outfits and stamping mills—from the solitude of the lonely prospector with his home-made apparatus to the mighty roar of a grand Treadwell with 880 stamps crushing 4,000 tons of quartz daily (average) and extracting from each and every ton a gross average of $2.20 of gold, a triumph in profitable mining of low-grade ore. To-day we hear of Treadwell, of Nome, of Fairbanks and of Tanana. To-morrow other names will occupy the center of the world's stage when a new Klondike or a new Nome is discovered.

Copper: In days gone by the Indians frequently appeared on the coast with great boulders of almost solid copper, which were traded to the white men for their wares. Till 1904, however, Alaska did not produce copper in any considerable quantities. In that year slightly over 2,000,000 pounds were sent out, and in 1906 nearly 9,000,000 pounds were exported. Alaska is a great copper country—just how great no one yet knows. In the Copper River district a railroad is being rapidly pushed from the coast inland to tap the wealth of the Bonanza mines, acknowledged to be the richest in the world, showing, as they do, $22,000,000 in sight, and development only well started. The Copper River activities are more fully covered under the heading "Transportation."

Coal: Incomplete surveys have now firmly established the fact that coal of the finest quality is in Alaska in abundance, equal to the best the East produces. That coal is widely distributed is shown by the accompanying United States government map, statistics of which give the known coal areas as being 13,882 square miles. Practically nothing has been done with the coal resources as yet, due to the lack of transportation facilities. Coal de-

PANORAMA OF FAIRBANKS, ON THE YUKON

VIEW OF NOME, ON THE SEWARD PENINSULA

posits are divided as follows:

	Known Coal Areas. Square miles	Areas of Coal-bearing Rocks. Square miles
Anthracite:		
Bering River	26.4	
Matanuska River	4.2	
	30.6	
Semi-bituminous:		
Bering River	20.2	620
Matanuska	20.3	
Cape Lisburne	14.2	
	54.7	620
Bituminous:		
Matanuska River	22	900
Alaska Peninsula	69	657
Yukon Basin	167	2,490
Cape Lisburne	205	1,255
Anaktuvuk River	9	68
	472	5,370
Total anthracite and bituminous	557.3	5,990
Lignite:		
Southeastern Alaska	10	50
Cook Inlet Region	304	2,565
Southwestern Alaska	16	300
Copper River		20
Yukon Basin	216	1,557
Bering Sea	52	426
Northern Alaska	83	1,736
	861	6,654
Grand Total	1,238	12,644

Tin: Tin has been found in an area embracing about 450 square miles in the northwest portion of Seward Peninsula, but as yet the returns from the mines in operation have not been commensurate with the investment represented. This is undoubtedly because of the pioneer and development character of the work, most of which has been done by two companies, *viz.*, the Bartells Tin Mining Company and the United States Alaska Tin Mining Company. Those who have made a study of tin prospects around Nome believe that tin is there in plentiful quantities and will soon become an important article of export.

Marble: This product has been found in several sections of Alaska, but only one quarry has been operated—that on Prince of Wales Island, located 650 miles from Seattle. Here the shoreline for nearly five miles presents an unbroken front of a superior quality of marble—a quantity sufficient to last an indefinite period under ordinary mining conditions, and of a quality equal to grades of Italian marble. Alaska marble is beautifully marked, is free from flint, and is of such texture as to be easily worked.

Silver: The market conditions of silver have not of late been such as to stimulate production of this metal, the 1908 output being but $20,132. Large deposits are known to exist, some of which are extremely rich.

Miscellaneous Metals: On the Chichagoff Island is a large deposit of gypsum, which is now being worked by a Tacoma company. In the Jade Mountains, in Arctic Alaska, are deposits of jade, and in other

WRANGELL, ALASKA

CORDOVA, ALASKA. THE TERMINAL CITY OF THE COPPER RIVER & N. W. RAILWAY

quarters sulphur, bismuth, mica, graphite; antimony and cinnabar are known to exist, but practically nothing has been done to date in exploiting these resources.

Petroleum: Surface indications of oil are shown in several parts of Alaska, notably around the coal fields of Katalla. Analysis has shown Alaskan oil to be of the very highest grade, but, although there are a few producing wells, oil is not as yet a commercial realization. Oil is distinctly one of the undeveloped resources.

Fisheries: Most people would be amazed at the statement that the fish industry of Alaska now gives a return one-half as great as the gold yield. Yet such is the case, and even with these $10,000,000 yearly returns the fishing banks are only being touched. In 1908 the total number engaged in fisheries work was 13,337, of whom 4,976 were occupied directly in fishing, 7,740 in canneries and other shore work, and 621 on transporting vessels. The total value of investment in the industry is over $10,000,000, a large proportion of which is concerned with the salmon catch. There were in operation in 1908 in Alaska 30 canneries, 39 salteries and 7 hatcheries. The output of canned salmon for the year was 2,606,972 cases (equivalent), each containing 48 one-pound cans, and this product is the very best the market affords.

Furs: Alaska has been the greatest fur-producing country in the world, the Russians having taken out about $100,000,000 in furs before 1867, and the Americans about $60,000,000 since that date. The inroads of civilization have reduced the returns to a bare $250,000 per year. The principal furs now obtained are those of the seal, otter, fox, marten, mink, wolverine, lynx, bear, beaver, ermine and muskrat. Considerable promise of future development is given by the fox farms and the reindeer herds, the latter of

VIEW FROM MEXICAN HEAD FRAME, SHOWING PART OF TREADWELL, WITH DOUGLAS CITY AND JUNEAU IN THE DISTANCE

A GOLD-MINING DREDGE IN THE SALMON RIVER, ALASKA

A BUCYRUS MINING DREDGE IN ALASKA. THE BUCYRUS COMPANY, SOUTH MILWAUKEE, WIS.

which are being developed under government charge.

Lumber: For the most part the timber does not grow large enough to figure much in export possibilities. Along the Yukon and in Southeastern Alaska, to elevations 3,000 to 5,000 feet above sea level, are good growths of spruce, birch and cottonwood. This lumber will find plenty of use in the home markets. A large portion of Alaska is void of timber of any sort.

Agriculture: So firmly fixed in the ordinary mind is the ice and snow conception that it is generally a new idea that Alaska has any agricultural possibilities. Yet there are in this Northland fully 100,000 square miles suited to agricultural and stock raising pursuits, and climatic conditions are not more severe than in many parts of the States. Where the growing season is short the long summer days compensate, bringing to harvest fullness all kinds of produce with tropical-like rapidity and giving a distinctive quality to vegetables and other produce not ordinarily found. Successful truck gardens abound in Alaska around Nome, Fairbanks and all mining centers, and grains and grasses of the hardier sort are being successfully raised over wide territories. Success is merely a matter of adaptation to the new conditions of climate and soil, and this pioneer work is being pushed as rapidly as possible by the Government at the various experimental stations. Under the direction of the expert in charge, Professor C. C. Georgeson, much is being accomplished in definitely determining the produce and varieties that can be successfully grown in the various sections of Alaska that are being settled. Experimental stations are in operation at Rampart, Copper Center, Fairbanks, Sitka, Kenai and

MAP SHOWING GOLD-BEARING AREAS IN ALASKA

The dotted lines show proposed railways; the full ones those already constructed. No. 10, Cook's Inlet to Yukon River, about 300 miles (proposed), and No. 11, Haines to Fairbanks, about 600 miles (proposed). No. 1 to No. 9, inclusive, refer to numbers in text.

Kodiak. Work at all these stations is showing satisfactory results in stock raising as well as in agriculture. It should not be understood that Alaska is being pictured as a country of large present export possibilities. Export conditions can easily follow when the country becomes further advanced, but the real present function of agriculture will be to supply the needs of home consumption, and this it should do if proper encouragement and direction are given.

A GREAT CIRCLE, THE SHORTEST SEA ROUTE FROM SEATTLE TO MANILA, PASSES CLOSE TO THE COAST COAL DEPOSITS OF ALASKA

TRANSPORTATION.

Roads and Trails: One reason why Alaska has remained for so many years a wilderness was because of the great difficulty of travel without roads or trails. This lack became painfully apparent with the first great gold discoveries, and the Government, in 1900, started active work on a trail from Valdez towards Eagle City. Since then active work has been going steadily forward under the supervision of Major W. P. Richardson. The demands have been so great that the commission has been forced to use the available funds at points most urgently in need, and, as a result, the work has been widely distributed. The total mileage constructed up to the end of 1908 was:

Kind of Road.	Miles.	Approximate Cost per Mile.
Wagon...	452	$1,500
Winter sled...	397	275
Dog and pack trail...	255	150

This road-building work will go on with increased activity, for of late Congress has recognized the needs

THE SHADED SPOTS INDICATE THE COPPER REGIONS OF ALASKA. THE LINES REPRESENT THE AVERAGE TEMPERATURES OF THE THREE SUMMER MONTHS

THE SHADED SPOTS INDICATE THE COAL REGIONS OF ALASKA. THE LINES REPRESENT THE AVERAGE TEMPERATURES OF THE THREE WINTER MONTHS

and is providing more liberally to meet them, the appropriation for 1908 being $250,000.

Water Routes: Nature's highways are naturally the first to be utilized in any new country. Probably 6,000 miles of navigable rivers are available in Alaska for large boat travel, and these are gradually being utilized by various navigation companies. From the States to Alaska is a distance surprisingly short to those who have been accustomed to think of Alaska as a land very far removed from all civilization, the distance being about 600 miles to Southeastern Alaska from the city of Seattle. Three large steamship companies operate lines which touch at various points, going as far as Nome in the summer months, and to Cook's Inlet, on the south coast, in the winter months. Travel can be accomplished in ease and luxury, for the excellent transportation service is supplemented by efficient mail, telegraph and telephone service, all of which have combined to make travel to Alaska popular for both business and pleasure.

Railways: The future of Alaska is dependent upon her railways, for no great advances can take place when transportation costs are prohibitive. Railway conditions are therefore of extreme importance. The map on page 536 shows 359.4 miles of road now constructed as follows:

1.—*Copper River and Northwestern Railroad* (standard gauge), building from Cordova to the Bonanza mines, a distance of 200 miles, with probable branches to the Nebesna-White copper zone; up the Copper River Valley, through the pass to the Delta, and down the Tanana Valley; and also a branch to the Bering River coal fields; miles of track ready for traffic at the close of this season, 105 miles.

2.—*Alaska Central Railroad* (standard gauge), building from Seward to the Matanuska coal fields; proposed extensions to the Tanana Valley; road completed to near the head of Turnagain Arm, 53 miles.

3.—*Tanana Valley Railroad* (nar-

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SALMON CATCH. ONE OF TWO SCOW LOADS OF 18,000 EACH, CAUGHT IN THIS TRAP

VEGETABLES FROM SOUTHEASTERN ALASKA

row gauge), from Fairbanks and Chena to Chatanika; connecting Fairbanks with the most productive creeks in the Fairbanks mining district, 46 miles.

4.—*Seward Peninsula Railroad* (narrow gauge), Nome to Shelton in the Kougarok mining district, 80 miles.

5.—*Seward Peninsula Railroad,* spur to the mines of the third beach line, known as the Pay Streak Branch, 6.5 miles.

6.—*Council City and Solomon River Railroad* (standard gauge), from Solomon, 35 miles southeast of Nome; to Penelope Creek, 32.5 miles.

7.—*Wild Goose Railroad* (narrow gauge), Council to Ophir Creek, 7 miles.

8.—*White Pass and Yukon Railroad* (narrow gauge), from Skagway to Whitehorse on the Yukon River, a distance of 112 miles; additional mileage, spur to Atlin, 4 miles, and spur from Whitehorse to the copper mines, 10 miles; Skagway to White Pass (mileage in Alaska), 20.4 miles.

9.—*Yakutat and Southern Railroad*

TYPICAL VEGETABLE GARDEN, JUNEAU, ALASKA

A REINDEER HERD. REINDEER ARE RAPIDLY BECOMING A VALUABLE ASSET OF ALASKA. TOTAL HERD NOW 20,000 AND INCREASING RAPIDLY

DEPARTURE OF THE FAST MAIL TEAM ON SEWARD PENINSULA RAILROAD, LEAVING NOME, ALASKA

(narrow gauge), Yakutat to Situk River, 9 miles.

The Alaska Central road is a very important enterprise, as the development of the wonderfully rich Matanuska coal fields await its completion. Work was carried on till the end of 1907, when construction ceased, due to financial difficulties. Over $4,000,000 had been expended in bringing to completion terminal docks, and 53 miles of road which proved unusually difficult and expensive of construction. A foreclosure sale is now announced for October 9, of this year, and as it is understood that the proceedings meet with the sanction of bondholders, including J. Pierpont Morgan, it is apparent that activities are soon to be resumed.

STEAMER PASSING THE WRANGELL NARROWS

The Copper River and Northwestern Railway is to extend from Cordova to the Bonanza mines, a distance of 200 miles. This road is being backed by the Guggenheim interests and is by far the most active project in the field. Fifty-three and one-half miles were in operation at the beginning of this season and construction work during this season will bring to completion approximately 110 miles. Supplies and materials will be put into the field this winter and it is expected that the road will be completed next year to the present terminal point, the Bonanza copper mines. The construction along this line is of the best type, being equal to heavy steam road construction of the States. The present work calls for sixteen steel bridges, ranging in length up to 400 feet, and nine of these are already in place. Seventy-pound Tee rails are being used and construction generally made of such type as to withstand the heaviest freight service. While it is not possible to forecast future developments, it seems probable that further development would carry the road towards Fairbanks, giving a total distance of some 400 miles. This road will be of the greatest importance in opening up the interior deposits of extremely rich copper, and the fact that strong money interests are behind the project give promise of marked activity on this line. The new city of Cordova, the tide-water terminal of the road, is by its extremely rapid growth reflecting this confidence.

ALASKA OF THE FUTURE

What then can we say the future holds in store for this Empire of the North? The answer is not plain, but in making an estimate we should remember that the trend of empire has ever been westward and that this is the final frontier land of America. No longer can the "Go west" advice be strictly followed. The young man of to-day must go northwest and his Mecca must become more and more this Alaska of the North.

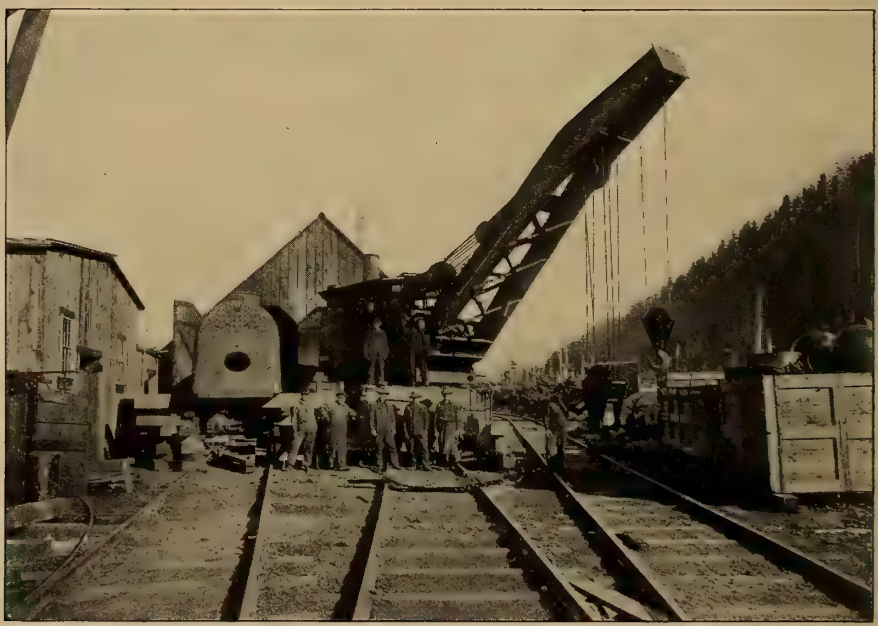
In judging the future we must look to the past and present as a basis for an estimate, and here again we must give the mineral wealth first place, putting gold at the head of the list.

STEAMER WHITE HORSE IN THE FIVE FINGER RAPIDS, ON THE UPPER YUKON

It surely is a great country where real money is lying loose in the earth and rocks, where a pan of unpretentious-looking sand will oftentimes

turn out to be $100 in gold. Since American occupation to the end of 1909 the gold produced will total close to $175,000,000. But the 300 tons that have come thus far comprise but a small part of the total. There is an almost inexhaustible supply of gold spread over at least 150,000 square miles of territory. Centuries will be required to exhaust the known deposits and the endeavor associated with this mining will be responsible for many new cities, modern transportation facilities, and successful agricultural development. The gold is there in plenty, snugly tucked away in the sands and rocks. What is needed are men, machinery and transportation which shall be adequate to efficiently handle the produce.

The copper resources cannot be judged by the production to date, as authoritative statements credit Alaska with having greater copper wealth than all the rest of the United States combined, and thus far comparatively little has been done in copper mining, due to lack of transportation facilities. By the end of 1910 this lack will be supplied in the Copper River, the Chitina and the Prince William Sound districts by interests representing Guggenheim and Morgan money. The construction of a $20,000,000 railroad by these interests from the coast to the Bonanza mines 200 miles inland and the building of the coast terminal city Cordova, with its docks and wharfs, must be taken as first steps in a great industrial development about to take place in the copper industry. Five years hence Alaska's copper output may equal in value that of the gold which is being produced.



WRECKING CRANE OF THE BROWNING ENGINEERING CO., CLEVELAND, OHIO, ON THE COPPER RIVER RAILWAY

Coal is a third great resource of Alaska awaiting development. No less authority than Alfred H. Brooks has said that the value of the high-grade fields probably exceeds that of the gold deposits. Practically nothing has been done commercially with these fields because of lack of transportation facilities, but here again we are on the eve of great development. The known coal bed and coal-bearing rocks cover an area of nearly 14,000 square miles widely distributed, but the most important fields are at two points, the

Matanuska, near Cook's Inlet, and the Bering River, near Katalla. Each of these fields contains the finest grade of anthracite coal, surpassing in quality and quantity the great fields of Pennsylvania. When it is remembered that no other anthracite coals are known to exist on the Pacific Coast, the real significance of the coal situation becomes more apparent. By the end of 1910, railways now building to these fields should be ready for operation, and 1911 will witness the beginning of an era of coal-producing activity. The known deposits comprise lignites and bituminous coals as well as the anthracite. When complete surveys shall have been made, it is believed that one-tenth of the total area of Alaska will prove to be coal-bearing.

Space will not permit detail mention of the remaining known mineral deposits. The real extent of wealth in silver, tin, iron, tungsten, antimony, gypsum, jade, sulphur, bismuth, mica, graphite, marble, precious stones and petroleum is unknown. The prospector has been too much occupied looking for gold strikes to think of these lesser possibilities. That there is wealth in all these lines has been definitely established by preliminary superficial surveys. These fields of industry will show their real strength when the country gets more settled. Till then we must recognize them as potential possibilities of uncertain dimensions.

PUTTING IN CONCRETE FOUNDATIONS ON THE COPPER RIVER AND N. W. RAILWAY

Parts of Alaska are well wooded, the cottonwood being the most widely distributed. The principal use of lumber will be for home consumption for years to come, but in the future the cottonwood may find much commercial use in the form of wood pulp for paper manufacture.

In agriculture Alaska can best be compared to the north countries of Europe — Finland, Norway and Sweden — where climatic and geographic conditions are similar. Their combined area is about the same as that of Alaska and climatic conditions, if anything, are more severe than in Alaska. Yet this territory not only supports a population of 10,000,000 people, but exports as well large quan-

ROUND ISLAND CHANNEL BRIDGE, ON COPPER RIVER RAILWAY

tities of agricultural products. Finland, with only 50,000 square miles of agricultural lands, supports 3,000,000 population, 90 per cent. of whom are engaged in agricultural pursuits. It is one of the finest dairy countries in the world, and it exports large quantities of butter, cheese, and of grains, chiefly oats. Yet Finland lies wholly north of the sixtieth parallel, whereas in Alaska this same line passes through the Prince William Sound country. It does not seem unreasonable to suppose that Alaska could support a 3,000,000 population, nor to assume that some future census will give her a 10,000,000 population. The gifts of nature are surely there; it only requires the effort of man to bring them to his service. The United States Government is hastening these results through the work of its several experimental stations and other pioneer work of an experimental nature.

The fisheries are another great asset. In the past this branch has yielded $115,000,000 of returns, most of which has come from the salmon catch. But the cod banks, of which there are 30,000 square miles, the finest in the world, have scarcely been touched. Herring, halibut and whales are abundant in these northern waters, and each represents large possibilities. Thus ought the fisheries easily to double and triple its present output.

Here, then, is a country within

SEWARD PENINSULA R. R. TRESTLE, LANE'S LANDING, ALASKA

TYPICAL SCENE ON THE COPPER RIVER RAILWAY

whose borders new wonders are ever developing, where untold mineral wealth of gold, copper and coal is to be had by simply going after it, where fish are so plentiful as to oftentimes be literally crowded out of the water on to the river banks, and birds so numerous as to sometimes cloud the sun, where wild game makes this a huntsman's paradise, and the grand array of snow-crowned mountains, crystal lakes, mighty rivers, majestic glaciers and awe-inspiring volcanoes combine to make this a scenic dream surpassing the far-famed Switzerland. Here a mere handful of men, working under pioneer conditions, without modern transportation aids, has yet converted from nature's storehouses wealth totaling one-third of a billion dollars in less than one-third of a century.

These are some of the things that give Alaska her right to the title "The Wonderland of America," that speak of her future greatness and that inspired the statesman Roosevelt to utter the prophecy, "The men of my age . . . . will not be old men before they see one of greatest and most populous States of the entire Union in Alaska, and I predict that Alaska, within the next century, will support as large a population as does the entire Scandinavian Peninsula of Europe."

Then will Alaska add several new stars to the American flag; then will populous cities, rich farming centers and great mining enterprises contribute their wealth to the nation; then will thousands of miles of railroad be built in this Northland, and hourly will trainloads of Alaskan produce be brought to these States to help supply the wants of their 200,000,000 population.

Then indeed will the Star of Empire beam in full splendor over Alaska, and "Seward's Folly" of '67 will stand completely vindicated in the hearts of a grateful nation.

WOMEN INVENTORS AND DISCOVERERS

By James Johnson

WHILE it is generally admitted that the feminine mind shows less activity than that of the masculine intellect in creative genius, there are, nevertheless, many admirable examples of woman's capacity in the realms of invention and scientific discovery. The record, therefore, of what woman has achieved in the field of invention makes it not unreasonable to expect more, in view of the great and widening advantages, educational and social, which she enjoys at the present day.

The popular Exhibition of Women's Industries held in Bristol upwards of a score of years ago gave sufficient proof of woman's inventive gifts in textile work, art products and clever inventions, supplemented by a variety of artistic and mechanical pursuits, illustrating the industry, skill and resources of women.

Among the numerous striking evidences of the inventive faculty of womankind may be mentioned several achievements by more or less popular names. At the famous 1862 Exhibition, *e. g.*, a woman exhibited a chain made with curious hoop-iron coils; and of more recent date an ingenious female mechanician invented a new valve for organs. The late Miss Harriet Hosmer, the gifted American sculptress of "Zenobia in Chains" and the "Sleeping Faun," patented some years back an invention for the conversion of lime into marble. More remarkable, a French lady, Madame Delong Tuyssusian, has received eighteen medals and diplomas at successive European exhibitions for a machine of her invention for cutting metal plates.

Very useful information is contained in the annual report of the British Patent Office respecting the number of applications for patents by women. A large proportion of these inventions by the fair sex, as may be supposed, have been mainly for articles of dress or for cookery and domestic economy. We learn that in 1901 there were 150 patents for the former, and 90 for the latter out of a total of 580, nor has the proportion varied much within the last year or two. In 1900 there were no fewer than 32 applications by women inventors for improvements in bicycles.

Concerning women inventors in the United States, useful data may be gleaned from an instructive volume in the London Patent Office recording the names and addresses of this class of workers, with the titles of their inventions, to whom patents were granted by the Government Bureau from 1790 to 1895. The contents supply an amazing revelation of the breadth and character of woman's inventiveness.

Here are a few typical cases: One of the handsomest models in the Patent Office is a submarine telescope of the year 1845, patented by Sarah Mather; another is an invention by Miss Montgomery of an improvement in locomotive wheels; while an ingenious contrivance for deadening the sound on elevated railways stands to the credit of Miss Mary Walton, of New York. To Miss Margaret Knight, of Boston, was granted likewise, in 1871, a patent for a valuable paper-bag-making machine.

Conspicuous in the list of mechanical devices springing from the

fertile brain of American womanhood are included a machine for driving barrel hoops, a steam generator, a baling press, a steam and fume box, an automatic floor for elevator shafts, a rail for street railways, an electric apparatus, a railway car safety apparatus, packing for piston rods, car couplings, electric battery, locomotive wheels, materials for packing journals, and boring machine for drilling gun stocks, a stock car, an apparatus for destroying vegetation on railways, another for removing snow from the tracks, a non-inductive electric cable, an apparatus for raising sunken vessels, a dredging machine, a method of constructing screw propellers, locomotive and other chimneys, a railway tie, a covering for the slot of electric railways, etc., an astounding record, indicating that where woman is free to make her own way in the world, and to employ her powers to the best of her ability, she is no mean rival of the lordly sex in the high excellence of her achievements on original lines.

In the department of research of a more directly scientific form good work is reported from British Universities by woman scientists, and similarly from American Colleges. To the lady workers at the University of Manchester, Professor Hickson pays unstinted tribute, equally confirmed by Sir William Ramsay, of University College, London, respecting the valuable aid in research activities contributed by women students.

Across the English Channel, scientific discovery is honoured in the person of Madame Curie of radium celebrity. Her triumph merits brief narration. Madame Curie won over her husband, Professor Pierre Curie, originally her tutor, to share her toils, and together they began their inquiry respecting the final contents of what is known as Bohemian pitchblende residue. Steadfastly they followed the scent, beset with difficulties which had repeatedly baffled other workers, and at length their herculean task was accomplished by the discovery of probably the most extraordinary "find" ever made in the universe of matter. In appearance, Madame Curie, of Polish nationality, has a frank, winsome and expressive countenance of unusual force of character and sterling qualities, and, as all the world knows, a woman of brilliant endowments, displaying a passion for science. Owing to the tragic death of her husband in the streets of Paris some time ago, Madame Curie has the distinction under these pathetic conditions of occupying his professorial chair in the University of Paris. It may be recalled that in 1903 the Royal Society of Great Britain gave a medal to Professor and Madame Curie for their joint investigation and co-discovery of radium.

The scientific activity of Madame Flammarion likewise calls for notice. Monsieur and Madame Flammarion are distinguished co-workers in astronomical science; the great astronomer's partner being no inconsiderable astronomer herself, having made an especial study of the planet Mars. It is probably not forgotten that this famous couple took rather a sensational honeymoon, choosing a balloon ascent in preference to any safer and more ordinary journey.

Modern science has been enriched by the discovery of Mrs. Ayrton, whose work in its bearings upon electrical science has been so highly appraised in scientific circles. Mrs. Ayrton's reputation is notable in the fact that she is the only woman member of the Institution of Electrical Engineers, a society numbering over 6,000 men. It is somewhat curious to read that, when in 1902 the gifted scientist was formally nominated for the fellowship of the Royal Society, the Council found that it had no legal power to elect a married woman to this distinction. It was decided, however, a few years later, in recognition of her experimental investigations on the electric

arc and also on sand-ripples, to present her with a medal, the first time that the Society has ever selected a woman since its commencement of presenting medals in 1731. The actual medal, by the way, which ton (née Miss Hertha Marks) displayed a talent for mathematics and enjoyed the ennobling influence of Madame Bodichon and Miss Emily Davies. After leaving Girton she studied electricity at Finsbury Col-

MADAME SKLODOWSKA CURIE, DISCOVERER OF RADIUM

Mrs. Ayrton received for her original work, was the "Hughes gold medal," together with the money prizes that accompanied it.

We learn that in the course of her Girton College days, Mrs. Ayrton lege and, in 1885, was married to the late Professor W. E. Ayrton, the well-known electrician, and henceforward adequate association was found for the development of her gifts. The contributions of

Mrs. Ayrton to science, in connection with the electric arc, have been numerous, including the completion of a series of experiments during the absence of Professor Ayrton in the United States in 1893. On the same subject she has read papers before various scientific bodies, the Royal Society being of the number. One of Mrs. Ayrton's most interesting researches, commenced in 1901, while at Margate, at the time of her husband's illness, took the form of a new and independent study of sand-ripples upon the seashore. The subject, it is said, "has opened up a wide

MRS. AYRTON, FROM THE PAINTING BY MME. DARMESTETER

field of inquiry regarding the action of water and cognate elements," now engaging her attention. In 1904 she read a paper on her investigations before the British Association at Cambridge, entitled "The causes and mode of growth of the ripples formed on the sea-sand by the outgoing tide," her theory being that sand ripples are formed entirely under water by the long, steady, seasaw motion of the waters. Referring to this assumption in connection with the Goodwin Sands, Mrs. Ayrton asks, might not some means be found of altering the trend of the sea, so as to keep it from forming the stationary waves which heap up the dangerous Goodwins? In demonstration of this she has invented various curious mechanisms, just as Madame Curie did to prove the existence of radium.

Noteworthy again, are Miss Gertrude Bacon's aeronautic discoveries, the outcome of daring balloon flights, of which she has published graphic descriptions.

Of the many names of eminent women of past generations and different countries who have adorned the annals of sciences those of Mary Somerville, Caroline Herschel, Miss Agnes Clerke and Miss Elizabeth Brown are, among others, worthy of remembrance both for researches and preparation of instruments by which to advance the progress of astronomy. Correspondingly, two Frenchwomen, Mademoiselle Jurin and Madame Mérian—the former by her astonishing discoveries in relation to bees, and the latter by means of her investigations bearing upon insect life in Guiana—have eloquently demonstrated that the eyes and hands of women are specially adapted for dealing with the smaller objects of creation. Added to this the gift of a rare patience, they easily take rank with the best scientific observers, such as Réaumur. In nature researches, as an entomologist, the late Miss Ormerod, who passed away in 1901, won deserved praise. Her devotion for a quarter of a century at great sacrifice of time and money, especially concerned with the problem of the effect of injurious fungi and insects upon agriculture and orchards, has been of incalculable benefit. Her labours in botany are being splendidly emulated by Miss Ethel Sargant. Supplementary to these various pioneers of science we are reminded of what Florence Nightingale has effected in Europe, and Clara Barton in America, by new, practical appliances for the relief of the wounded on battle-fields, of which the journals, etc., issued by the "Red Cross" movement, have made known to the world.

Another remarkable woman, Madame Sarah Bernhardt, has frequently displayed capacity other than that seen on the stage. One of her recent avocations of a highly original stamp was the casting of fish in plaster moulds, in order to form quaint designs in the "art nouveau" style. The prima donna of French theatrical genius works these in marble, bronze, silver or gold, and about three years since was engaged on a decorative fountain after this fashion. Several of her designs have been adapted and used rather effectively by Lalique, the renowned French jeweler.

From these and like examples of gifted womanhood we may safely infer that, with nearly all the employments being open at the present day to educated and enterprising women, the score of their inventions must increase both in value and distinction.

THE CONSTRUCTION OF CONCRETE DAMS

By F. M. Hoadley

AMONG the important structural problems which the civil engineer is called upon to solve, one of the most prominent, both by reason of cost and of consequence of its results, is the masonry dam. At the present time, when the whole subject of the conservation of water supply, both for power and for irrigation, is under interested consideration, the question of the application of modern methods to the construction of dams forms, therefore, a matter for careful study.

The masonry dam, under the older systems of construction, owed its value and security to its massiveness. As examples of brute strength, so to speak, some of the older dams are illustrations of engineering methods in which the resources were limited to the opposing of forces by masses, and in which the actual distribution of stresses was but imperfectly understood. Even at the present time, or, within a few years, the whole theory of the distribution of stresses in masonry dams has undergone revision, and the work of two professors at University College, London, has recently caused a re-examination of the proportions of some of the most important structures in existence.

It has been assumed that a dam "must be secure against sliding on its base or any plane within the body of the dam, against overturning, and against crushing of the material at any point and consequent opening of a seam at either face of the dam." Compliance with these conditions has led to the design and construction of great masses of solid masonry, capable by their weight, and by the friction of their bases upon the foundation, of resisting any sliding action; and designed, as regards section, to compel the pressure to act at such a leverage as to be incapable of causing failure by overturning.

The vital question of shear has been taken up more recently, while the use of masonry of the highest class has been considered as the best preventive of crushing.

The advent of concrete into general structural work, both in the plain and the reinforced forms, has directed attention to the special applicability of this material for the construction of dams, and with the consideration of concrete as a possible material there has naturally come also an appreciation of the immense advantage of a material which permits the control of the internal structure of the barrier.

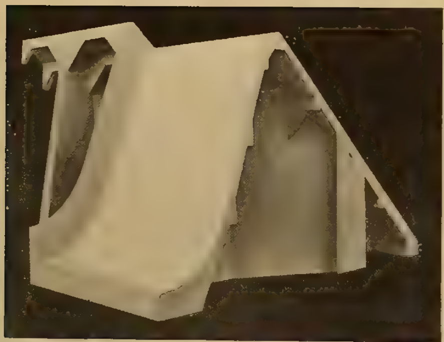
There has thus come into the province of the engineer the reconsideration of the design and construction of dams, with the result that it has been found practicable to replace the solid structure of masonry by a hollow one, of one-half to one-third the weight, and of much lower cost, while having, at the same time, as great, if not greater strength and stability.

It might seem as if the greater simplicity of the massive dam should give it preference, at least in many instances, but, upon examination, the masonry dam is seen to be by no means the simple structure which it at first appears. The mass must be carefully computed and proportioned to prevent rupture or overturning at times of maximum flood.

DOWN-STREAM VIEW OF DAM AT BARRE, MASS.

The heavy burden involves a correspondingly large and deep foundation, with all the concomitant difficulties encountered in the form of ground water, subterranean springs, and percolation. The necessity for

COMPLETED VIEW OF DAM AT BARRE, MASS.



PERSPECTIVE VIEW OF A SECTION OF THE RANSOM HOLLOW DAM

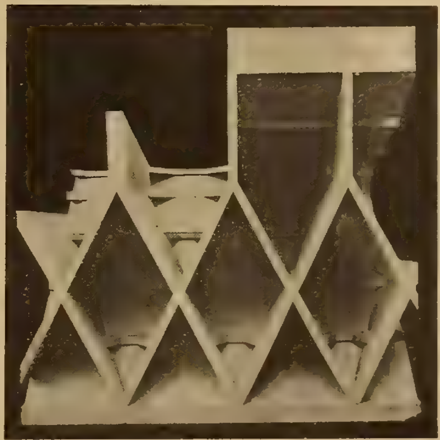
perfect union of base with foundation, both to prevent sliding and to avoid the penetration of water, tasks the ingenuity of engineer and constructor to the utmost. Even after all has apparently been successfully accomplished at great cost and much effort, the actual conditions in the interior of the structure, both at the time of its completion and at periods thereafter, are practically unknown; unless, perhaps, the failure of the whole reveals some undetermined weakness.

The adoption of concrete as the material for dam construction has enabled many of the former difficulties to be overcome or minimized. By substituting a hollow for a solid structure, the weight is correspondingly reduced. This avoids the dangers of upward pressure, since any percolation into the interior cannot accumulate, but passes away gradually as it enters. Forces tending to cause failure by sliding or by overturning may be met by giving the structure such proportions that the resultant of all the forces due to any maximum head of water shall always pass well within the base, a matter readily accomplished with such a material as reinforced concrete.

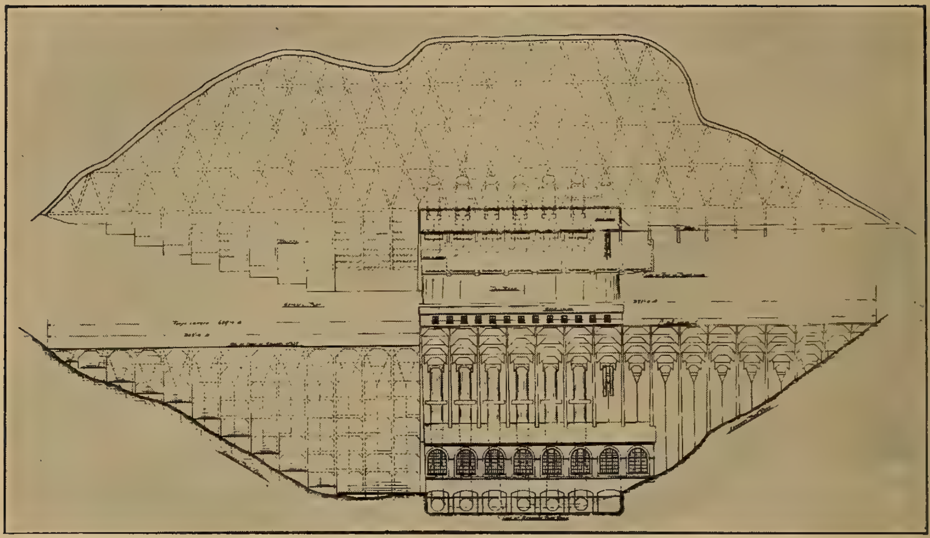
Failure by crushing must, in any case, be prevented by the provision of ample strength. This need not involve massiveness, and, indeed, it is better attained by a cellular construction than by the use of solid masonry. The problem is thus reduced to a matter of correct proportions, combined with such a distribution of material internally as will provide an ample factor of safety against crushing; a problem entirely capable of successful solution.

One of the recent systems for concrete dam construction, following out the above fundamental principles, has been developed by Mr. W. M. Ransom, and in the accompanying illustrations some of the salient principles of his method are indicated.

The actual barrier to the water is found in the up-stream face of the dam, this being reinforced as may be necessary by the use of steel bars, and carried to any required depth into the interior of the underlying strata to effect a complete union. The slope of this face is made at such an angle as to cause the resultant of pressure to fall nearly through the centre of the base, throwing the pressure downward upon the foundation and maintaining the stability of the structure. Behind this up-stream face comes the backing by which it is supported, and by which the pressure is carried down to the foundation.



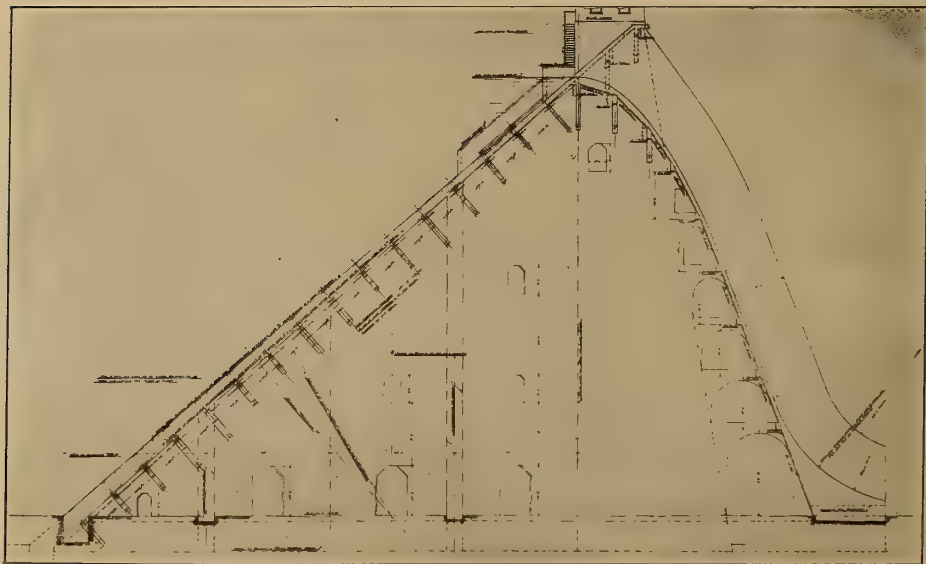
VIEW LOOKING UP INTO THE DAM FROM THE BOTTOM, SHOWING ARRANGEMENT OF DIAGONAL WALLS WHICH SUPPORT THE DECK, ALSO ARCHES WHICH CARRY THE LOAD OF THE DECK ONTO THE WALLS



GENERAL PLAN AND ELEVATION OF THE RANSOM HOLLOW DAM

This backing consists essentially of a system of interior walls, forming a cellular construction consisting of diagonal elements, dividing the interior of the structure into a series of chambers, upon the arched roofs of which the face of the dam is supported. Such a structure may be made entirely monolithic, while, by its hollow character, the temperature stresses are minimized, while, at the same time, a sufficient degree of elasticity is provided to prevent any injury from expansion and contraction.

In many instances in which re-



DETAIL CROSS-SECTION THROUGH SPILLWAY OF RANSOM HOLLOW DAM

inforced or plain concrete has been substituted for solid masonry there has been little material modification in the general design of the structure. It might be a simple matter to build a reinforced concrete dam along the same lines as those already long used for solid masonry dams, but, instead, it has been found that the newer material has enabled a new design to be developed, one which possesses many advantages, and which, as it comes into general and extensive use, may supersede the older type. Already in the dams which have been constructed a material economy in material, in cost, as well as a great saving in the time of construction, has been effected, and in some of the larger structures projected, for which computations and estimates have been made, still greater advantages appear. There is thus every reason to believe that the application of concrete to the construction of dams, for moderate and for high heads, will lead to the introduction of improvements of a more radical nature than have appeared in other departments of concrete work.

THE INTERNATIONAL CHEMICAL CONGRESS

By John B. C. Kershaw

THE Seventh International Congress of Applied Chemistry, held in London from May 27 to June 2, was the most successful of the congresses yet held; an attendance of over 3,000 members having been registered, and papers numbering nearly 1,000 having been read and discussed.

The Congress is now divided into seventeen sections and sub-sections, and in several of these, papers of great interest to engineers were presented for reading and discussion. Limits of space render it impossible to deal in an adequate manner with the whole of these papers in CASSIER'S MAGAZINE, and we can only give a short resumé of those papers we have selected from the list as likely to prove of special interest to our readers.

The well-known metallurgist, Mr. John E. Stead, F. R. S., of Middlesboro, presented a valuable paper, giving the results of recent research work on the subject of alloys of iron, carbon and phosphorus, and explaining the origin and composition of the white bands—known as "ghost lines"—which can be seen under the microscope, in samples of commercial soft steels after rolling.

The most important of the conclusions were as follows:

That the eutectic of both gray and white phosphoretic pig-irons, at the time of initial solidification, is practically identical in composition.

That during the solidification, and in cooling down afterwards, of pig-irons which are white when cold, the ternary eutectic, containing about two per cent. carbon and seven per cent. phosphorus, remains as such in the cold metal.

That the eutectic when still liquid in gray pig-irons is practically the same as that in white iron, but, during solidification and afterwards, when cooling down, the carbon diffuses out of it, and there remains in the cold metal a binary eutectic of iron and phosphorus practically free from carbon. This was proved by expressing by hydraulic pressure the eutectic from the nearly solidified metal, analyzing what was squeezed out, and by examination of the corresponding gray iron under the microscope.

That whereas the phosphorus and carbon segregate round the crystals in the metal which solidifies last, the carbon during the cooling down diffuses out of the envelopes into the parts of the crystals which were initially nearly pure iron, and is concentrated there.

That rolled steels containing little carbon, such as boiler plates, etc., almost always contain bands of ferrite free from carbon, and strings of particles of pearlite embedded in ferrite, also in bands. The white bands have been called microscopic "ghost lines." They represent the elongated envelopes of ferrite which surround the crystals in the cold cast steel, and are higher in phosphorus than the pearlite bands. This banded condition is normal in commercial soft steels in the rolled condition, and, judging from the result of much research, cannot be avoided without almost entirely eliminating the phosphorus. The white bands are more pronounced the higher the phorphorus.

Mr. Edward R. Taylor, the chairman of the conservation committee of the American Electrochemical Society, presented a paper on the National and International Conservation of Water-Power. He is of the opinion that every scientific society should

have its conservation committee in order to direct attention to the enormous importance of the question, and to organize national and international methods of dealing with it. In New York State alone, 1,500,000 horse-power is stated to be available—with proper conservation of the water—while the water-power capacity of all the States of the Union is estimated at the enormous figure of 150,000,000 horse-power.

Private enterprise alone cannot undertake the development of these enormous resources of water-power, as the capital outlay required is too huge, and in some of the more recent large water-power developments in the United States (e. g., Massena) have not proved financially successful. On the other hand, the Nation can command cheap capital—can put the excess power to stone crushing and other public services—and can stand without strain the waiting period until more valuable markets for power are developed. References to China and Babylon were made to show the folly of neglecting the conservation of water—and we are surprised Mr. Taylor did not refer to the brilliant work and discoveries of his countryman in relation to the canals of Mars—to show the possible value in the later stages of the earth's development, of scientific knowledge and forethought, in connection with this question. Mr. Taylor closed with an appeal for the appointment of a conservation committee for the Congress of 1912, and intimated that possibly the New York meeting would be signalized by the creation of a *section* dealing altogether with this subject.

The paper on The Utilization of Atmospheric Nitrogen, by Dr. A. Bernthsen, director of the Badische Anilin und Soda Fabrik, aroused more interest than any other paper read before the Congress—a result due partly to the importance of the subject, and partly to the fact that a demonstration of the improved arc process, patented by the Badische Company, was to be given. The inventors of all the more important commercial processes for manufacturing nitrogen compounds were present during the reading of Dr. Bernthsen's paper; and a lecture theatre double the size would hardly have sufficed to accommodate all who wished to hear the paper and to see the striking experiment by which it was illustrated. The new arc process for bringing about the union of the nitrogen and oxygen of the air is the invention of Messrs. Schonherr and Hessberger, two engineers in the employ of the Badische Company, and was patented in 1905.

It is not a mere modification of the Birkeland and Eyde process, as has sometimes been falsely assumed, but differs fundamentally from it, for while Birkeland and Eyde cause the electric discharge to burn in a strong magnetic field, and thus spread it out in the shape of a flat, more or less circular disc, Schonherr dispenses entirely with magnets and magnetic fields, and produces his arc inside an iron tube of comparatively small diameter, at the same time passing the air through the tube, and thus bringing it into contact with the arc. The manner in which the arc is developed is in itself very peculiar and interesting. The iron tube, or arc tube, contains an insulated electrode at one end, and can itself serve as the second electrode. The arc, at its formation, springs from the insulated electrode to an adjacent part of the arc tube, which is only a few millimetres away, but the air, which is passing through the tube, being preferably introduced with a tangential or rotary motion, immediately carries the end of the arc along the wall of the tube, so that it either enters the tube at a considerable distance from the electrode or it ends on a special electrode placed for the purpose, say, at the other end of the arc tube. A slight modification consists in using an arc tube of non-conducting material, and inserting in it a wire spiral along which the end of the arc can travel, or providing other means for bringing about the initial formation of the arc. In each case, a col-

umn of arc flame is obtained, burning quietly in the axis of the tube, and surrounded by the air which is being passed through the tube. The arc, as seen through a mica-covered opening, emits an intense light, and is quite stable, whereas arcs which are formed in the open air are easily extinguishable. The air passing through the tube comes into contact with the arc, becomes partially converted into nitric oxide, and is then rapidly cooled down by contact with the outside layers of air, and consequently a decomposition back again to nitrogen and oxygen is avoided. The cooling action is still further increased by surrounding the upper end of the arc tube with running water, after the manner of the Liebig's condenser. The gases leaving the tube contain about two per cent. of nitric oxide, and are therefore from one and a half times to nearly twice as concentrated as the gases which Birkeland and Eyde produce.

The first large factory erected by the new Norwegian companies will be situated in the interior of Telemarken on the Rjukan, one of those immense waterfalls in Norway. The total fall of 1820 feet is divided into two steps, and, with a flow of about eleven thousand gallons of water per second, is capable of yielding a quarter of a million horse-power. The upper fall is now being developed, and with ten turbines will provide about 140,000 horse-power. It is expected that the factory will start running in about two years' time. The saltpetre will be carried along 29 miles of new normal-gauge railway, and by a ferry along Lake Tin, which is 25 miles in length, until it reaches Notodden. From here it will be transported via Skien to the sea. An experimental plant on the system of the Badische Anilin & Soda Fabrik is being constructed there, in order to determine which type and size of furnace is most suitable for erection at Rjukan. Water power on the Matre and on the Tyn in West Norway have been acquired, and will be held in reserve for future use.

In Germany the water power suitable for the production of saltpetre is very limited. In South Bavaria the Alz is able to supply sufficient power for a moderately large factory, and negotiations have already taken place with the Bavarian Government with regard to a scheme for the production of 50,000 horse-power and the erection of a factory near Burghausen.

A paper on the Thermal Calculations on the use of Caseons-fuel in Blast-furnace Practice was contributed by Mr. Louis Katona, of Buda Pesth. In this paper the author gave a large number of thermal calculations showing the heat losses that occur by the present methods of iron and steel manufacturers. A modified form of furnace, in which a mixture of fuel gases, such as carbon monoxide, methane and hydrogen, replace the coke of the ordinary blast-furnace practice, and the lime-stone is greatly reduced in amount, was suggested finally as the most economical and satisfactory substitute for the old form of blast furnace.

The author stated that it is a well-known fact that carbon monoxide, hydrogen or methane act as reducing agents to oxides of iron at low temperatures, i. e., 400 degrees to 500 degrees C. In the solution of the problem proposed, iron ore at a light red heat is brought into contact with carbon monoxide, hydrogen or methane, similarly preheated to a red heat in a shaft furnace. The design of the furnace will thus strongly resemble that of the blast furnace of to-day, but it will be somewhat smaller in diameter, the coke space having ceased to exist. The limestone space will also lose some of its proportions, as less limestone will be necessary, there being no ash from the fuel requiring liquefaction and only enough limestone will be used to yield a liquid slag.

The structural solution of these considerations was shown in drawings. The furnace itself is divided into two independent parts. The gas tuyéres are arranged on the dividing line between these two parts. The lower part receives and holds the molten iron

and slag, and is constructed as a ladle. It may be removed for the handling of metal or for repairs. The shell is made of steel plate and the lining of dynas bricks in the neighborhood of the hearth and of chamotte bricks in the upper parts of the bosh. The hearth or ladle is lined most conveniently with magnesite bricks.

Mr. J. B. C. Kershaw, of Liverpool, gave a short address on the subject of The Scientific Control of Fuel-Purchase. The author summarized the arguments for a reform in our present methods of purchasing fuel as follows:

Coal itself is of a variable composition and value, and when mined from the *same* seam in the *same* mine is not always of uniform chemical or physical composition.

The seams of coal also alter in character and become worked out in time, and consequently no guarantee that the fuel is from a certain seam can be accepted as a standard of value.

The moisture and ash contents of fuel vary within wide limits and are dependent upon such indeterminate factors as the state of the weather and the care used in the actual mining operations.

The cost of fuel is the largest item in many manufacturing industries, and there is no reason why the methods used in the purchase and control of other important raw materials should not be applied to fuel.

The methods of scientific control advocated by the author and others who have made a special study of this question were then described in detail, and the basing of fuel contracts upon calorific value, instead of upon mere tonnage, was suggested as the system by which fuel will be sold generally in the near future. Details of the progress made in the adoption of this more scientific method of fuel purchase in the United Kingdom, Germany and the United States were finally given. (CASSIER'S MAGAZINE of May, 1908, contains an article by Mr. Kershaw on this subject.)

A paper upon the "Problems Involved in the Production of Power-Gas from Low-Grade Fuels" was read bv Mr. B. G. McLellan, of York. The author pointed out that, in consequence of the increased price of the class of fuel most suited for use with the ordinary type of gas-producer (pea-nut anthracite), the natural course of development for gas-producer practice lay in adapting the gas-producer to the cheaper grades of fuel—that is, to the particular class of fuel which could be obtained most cheaply in the locality where the producer was required to work.

Mr. McLellan then dealt with the difficulties attending upon the use of bituminous or coking coals, and of fuels high in ash contents, for producer work. Dealing with the latter point first, the author stated that the proportion of ash present in the fuel was of great importance when high duty was demanded of the producer, especially if this ash were of a fusible nature. Briefly stated, the conditions favouring the formation of a fused, hard clinker were: (1) a high percentage of fusible ash; (2) a thick fuel bed, and (3) a low-steam or air-jet temperature.

M. Marconnet, of Paris, had invented a producer which aimed at the removal of these troubles. In this apparatus coal dust was employed—the coal dust and air were blown into the producer in the proper proportion—and the heat generated was so intense that the ash was melted and might be tapped-off at the bottom.

As regards gaseous impurities, the gas which came away from gas-producers using bituminous coal was charged with soot or tar, and under ordinary conditions of work this soot and tar had to be settled or scrubbed out. Many designs of down-draft producers and double-zone producers had been tried (chiefly in America and Germany) in which the soot and tar are consumed, but it was difficult to predict how they would succeed on our English bituminous caking coals.

It was certainly most unsatisfactory to produce gas in a comparatively

small apparatus, and then to require a cleaning plant, taking up to ten times the space—or even more—required by the producer, in order to cleanse this gas before the engines could make use of it, especially as the impurities removed from the gas were combustible, and therefore of thermal value.

The aim of those working on the subject, therefore, should be to construct a producer which would turn out a gas requiring much less purification. This was a subject which had been neglected by chemical technologists in this country. It had been left almost entirely to engineers, whereas it was a problem demanding the most careful study of a chemically-trained mind.

Mr. A. B. Searle, of Sheffield, contributed a paper on the same subject, with special relation to the use of the gas produced for smelting various metals.

The author stated that he had been working at the practical solution of this problem for some years, and that the chief difficulties met with had been those due to variable composition—the ash ranging from 20 per cent. up to 40 per cent., and even 60 per cent. in different deliveries of the fuel. In consequence of this great variation a producer with a great depth of fuel and a large gas-holder had been found necessary in order to obtain good results when burning the gas. Another difficulty was that arising from inadequate air supply, and to overcome this injectors had been employed, preferably worked by compressed air rather than by steam. The burning of the gas produced also gave rise to other difficulties, and the manner in which the air was conveyed to the gas was found to affect the length of flame and completeness of combustion very materially.

Limits of space will only allow the titles and names of authors of the remaining papers we have selected to be given, and readers interested in these must refer to the official report of the Congress for the further knowledge of their contents.

A. C. J. Charlier, London.—The action of hydrogen, nitrogen and other gases on metals, particularly on iron and steel.

R. H. Richards, U. S. N.—A study of some laws relating to ore concentration.

M. Strap, Paris.—Etat actuel des Mines d'or francaises.

Werner Cronquist.—Ferro-silicon.

J. B. Williams, Brazil.—Chemistry of alluvial gold mining.

P. Weiss, Zurich.—Le Ferromagnetisme et l'étude des Metalles et Alliages.

M. Jarl.—Kryolith.

R. Schelle, Selmeezbanya. — Darstellung von reinem Tellur.

Professors Marte and Will.—Zur Untersuchung der Sprengstoffe auf Zundsicherheit in Schlagwettern und Kohlenstaub.

Clausel de Coussergues.—Etat actuel de l'électrosiderurgie en France.

L. Revillon, Paris.—Emploi industriel de la metallograf microscopique.

THE NURNBERG GAS ENGINE

By Richard Bechtel, A. M. Inst. M. E.

The following article is condensed from a very full and interesting paper presented recently before the Birmingham Association of Mechanical Engineers reviewing the development of the large gas engine in general, and that type known as the Nurnberg engine in particular. As an example of one of the highest forms of the large internal-combustion engine, originating on the Continent, and extending in manufacture and use into England and the United States, this engine demands interested attention of the engineer, and we believe that this abstract of Mr. Bechtel's paper will be found entirely welcome.—THE EDITOR.

FOR a modern gas engine to be really reliable and capable of competing fully with large steam engines in every respect, the following points are of vital importance:

(A) To proportion every part to resist, without risk, the maximum possible working stresses. This can only be obtained by the careful calculation of every part upon scientific basis, and by making use of the extensive practical experience of the manufacturer of large steam engines already existing.

(B) To use only such materials as are suitable for the respective conditions; and in support of this attention need only be directed to the difficulties which have been experienced in obtaining the right composition for gas cylinder and piston castings. The experience obtained by the manufacture of small gas engines is of a relatively low value, and in the design of many parts of the large gas engines had to be entirely dispensed with. This is not a merely theoretical consideration, but is based upon practical experience, as high-powered gas engines, designed similarly to small gas engines, have generally been a failure.

(C) To allow ample wearing surfaces for the reduction of wear and tear to a minimum.

(D) To secure easy accessibility to all parts where necessary.

(E) To have an effective, well arranged and safe cooling system.

(F) To provide for the best possible methods of lubrication.

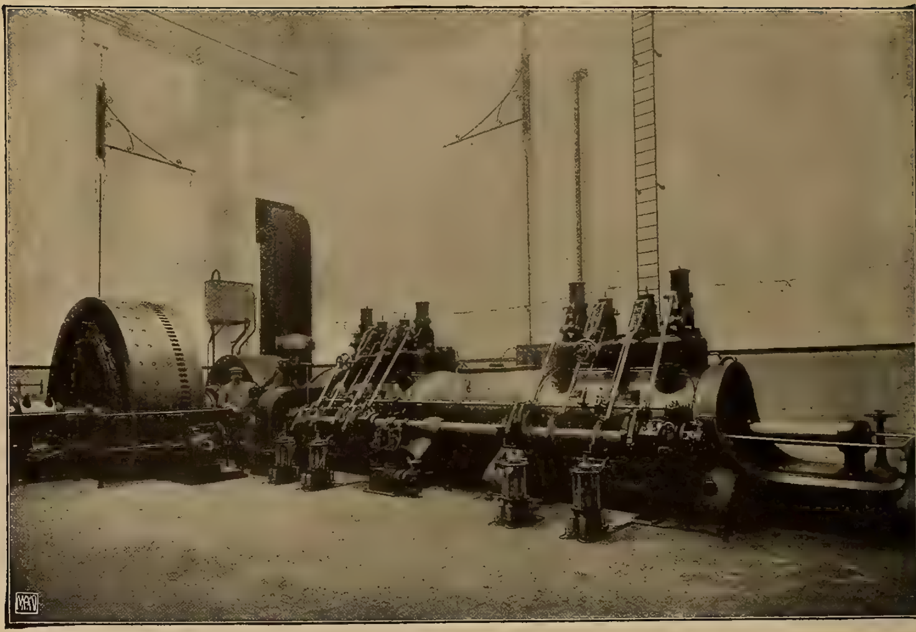
(G) To equip the engine with a reliable ignition.

(H) To design the engine so that cheap machining methods can be applied, thus reducing the selling price to a minimum.

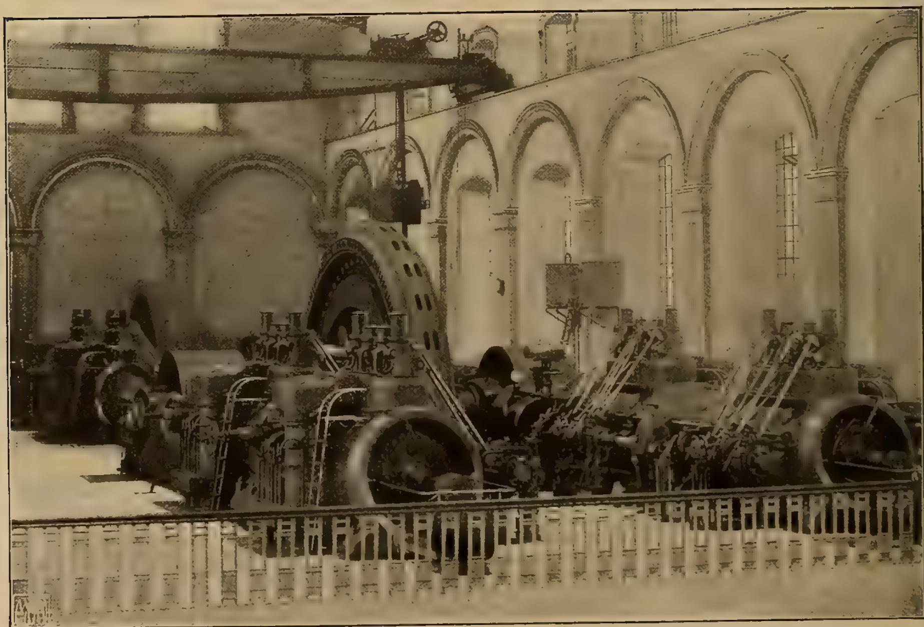
Taking up these several points so far as they have been considered in the design and construction of the Nurnberg engines, the following details may be mentioned:

In the first place, the Nurnberg engine works on the four-cycle principle, generally called the "Otto" cycle, and is double-acting, having the cylinder ends closed, enabling both sides of the piston to receive power impulses. These engines are generally made with two cylinders, arranged tandem when the space permits, or with cylinders side by side when the location renders this form preferable. For very large sizes four cylinders are used, the twin-tandem arrangement then being adopted. In this way engines of sizes from 400 to 6,000 brake horsepower are designed for a great variety of service.

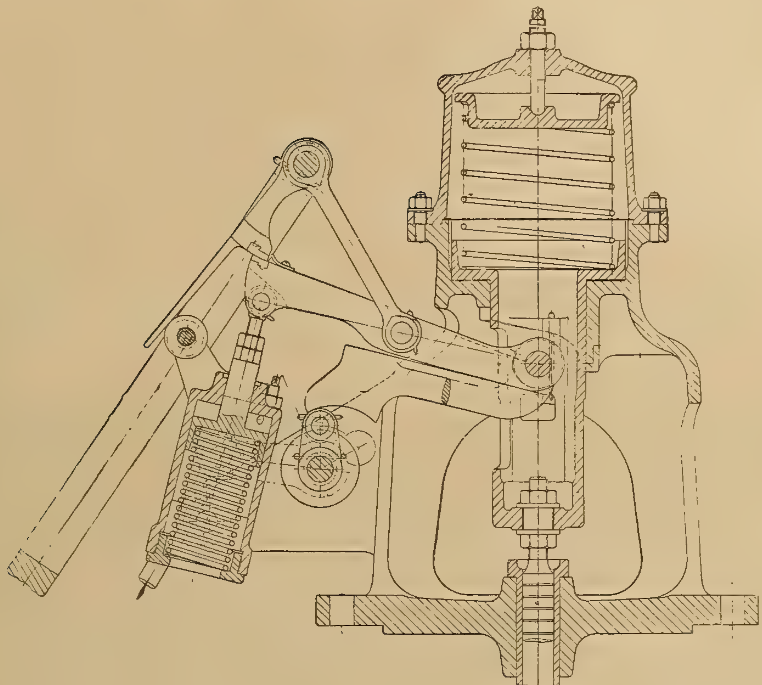
The general design of the engine is shown in the various illustrations. The arrangement of the main parts is: bed-plate, first cylinder, connecting piece, second cylinder, and rear guide. The bed, as shown, is a heavy ribbed box casting, the sides being kept below the centre line of the engine, to permit easy access to



TANDEM GAS ENGINE AT THE BRYMBO STEEL COMPANY, LTD., BRYMBO, ENGLAND



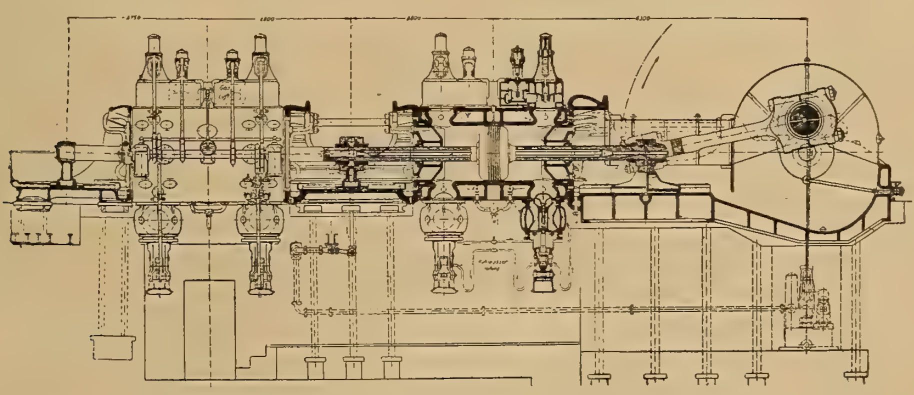
FOUR-CYLINDER, TWIN-TANDEM GAS ENGINE AT THE POWELL DUFFRYN STEAM COAL COMPANY, LTD., BARGOED COLLIERY, ENGLAND



TYPE OF GAS VALVE GEARING USED ON NURNBERG GAS ENGINES

the cross-head, a strong tie-rod giving further strength to the whole construction. The principle of centrical fitting is applied to the entire design of the engine, this insuring accurate alignment and, at the same time, permitting easy access to all working parts.

In the Nurnberg engines the cylinder lining and the jacket are cast in one piece, and in order to minimize the bending stresses in the flanges the distance between the liner and the outer wall of the jacket is large, this construction also giving ample space for the cooling

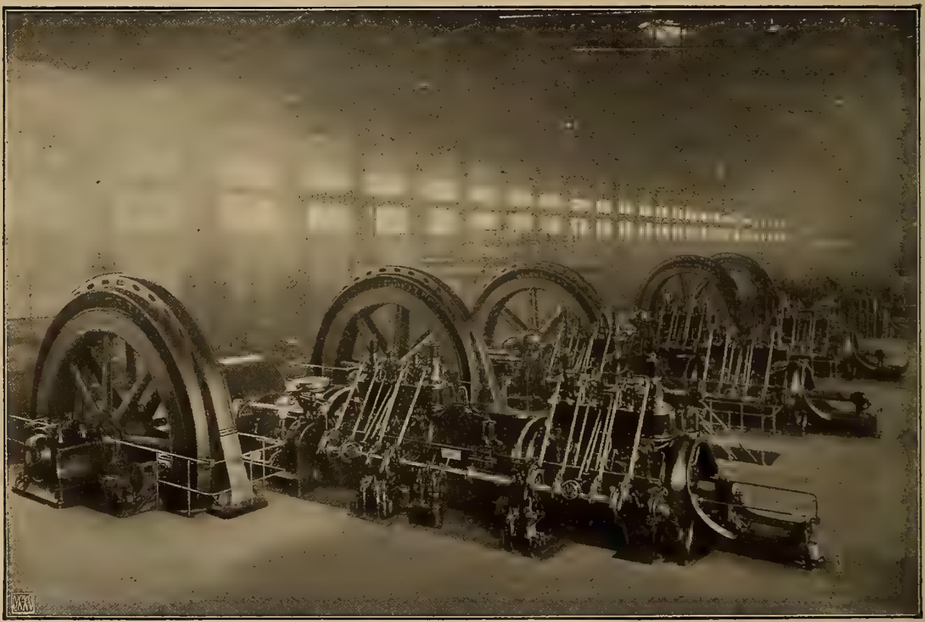


LONGITUDINAL SECTION OF A NURNBERG TANDEM ENGINE

water and permitting the space to be readily cleaned. By adopting this design a high degree of stiffness is secured and deflection of the cylinders by their own weight avoided.

The inlet valves are placed on top of the cylinders, and the exhaust valves beneath, the most satisfactory method of providing for the discharge of any dust mechanically carried into the cylinder with the gas, practice having shown that it is impossible to remove all the particles from the charge. Difficulties of cracking at the points where the valve ports connected through from the cylinder to the jacket walls have been overcome by the combination of suitable material, special methods of moulding and casting, and the use of the best configuration of the ports and proper distribution of the metal. The valves and their spindles, as well as the valve casings, are water-cooled, and the arrangements are such that both valves and valve-seats can easily and quickly be taken out for inspection and cleaning without dismantling or removing the pipes.

A special gas valve is provided independently of the inlet valve, by which the quantity of gas to be absorbed is regulated, this being controlled by the governor. The speed regulation is therefore effected by the so-called "quality" method, the proportion only between the gas and air being altered, according to the load on the engine, and the quantity of the mixture sucked in being constant; the compression therefore remaining constant also. A special regulation of the charge may be made by a pair of butterfly valves, independently operated by handwheels, these to be used for starting purposes.



INSTALLATION OF NINE NURNBERG GAS ENGINES (12,750 B.H.P.) AT THE HASPER EISEN UND STAHLWERKE, WESTPHALIA, GERMANY

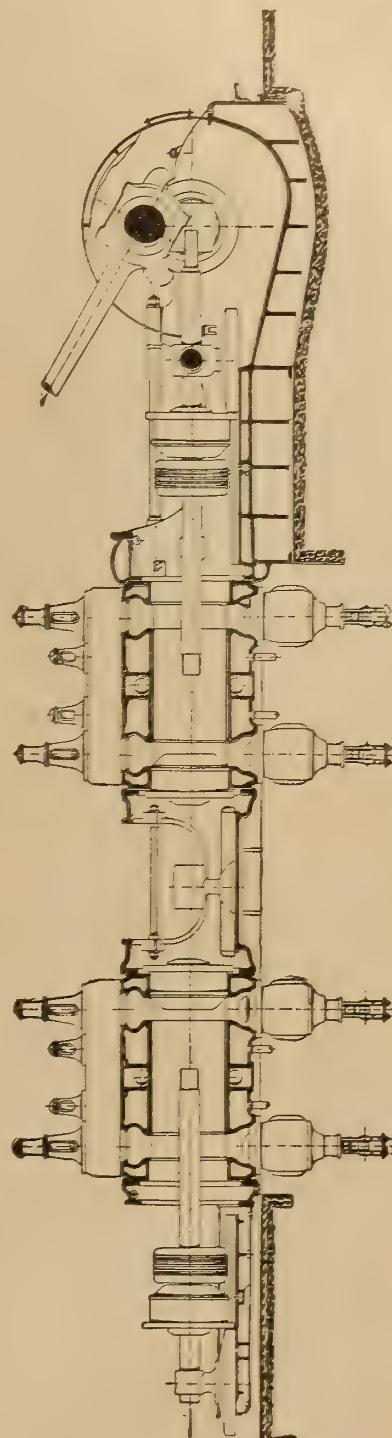
The gas inlet valves are operated by a trip valve gearing, the details of which are shown in the illustration. The valve itself is connected to a rolling lever, which in turn is linked to two small connecting rods to a trip lever, moved by an eccentric rod.

The rolling lever, to which the

valve stem is fastened, slides along a rolling path, which is supported on one side by a pivot, adjusted by the governor. On its downstroke the trip lever engages the rolling lever, and thus lifts the valve. At a certain point the disengagement of the trip lever takes place, and the valve is pressed down by a spring. Dashpots are provided to deaden the fall, a large one in the spring cap, and a smaller one coupled to the rolling lever. According to the position which the governor causes the pivot to occupy, the time of the opening of the valve and its lift is determined. The closing point of the valve is constant for all loads.

For blowing engines, where uniformity of speed is not of so great importance as for other work, a very simple gas valve gearing is used. It is of exactly the same design as that of the inlet gearing, with the single exception that the bottom rolling lever is adjustable, not by the governor, as in the first described gearing, but by a pivot, which is regulated by hand. In this case only a safety governor is applied, which switches off the ignition should the speed of the engine surpass the maximum allowable number of revolutions. The governor is of the well-known Hartung type, and is driven by machine-cut spiral wheels. The governor gear shaft, which runs alongside the cylinders, is carried by swivel bearings, or recently by ball bearings.

The method of cleaning the cylinders and pistons of the Nurnberg engine is well shown in the illustration, this cut showing the manner of removing the front and rear cylinder heads, and of attaining access to the interior of both cylinders. Similar methods give access to the valves, so that the operation of cleaning is readily performed. Experience has shown that the dismantling of the four gas and inlet valves and their proper cleaning can be done in half a day, and that of the exhaust valves in about a day. The exchanging



CLEANING OF CYLINDERS AND PISTONS OF A NURNBERG GAS ENGINE

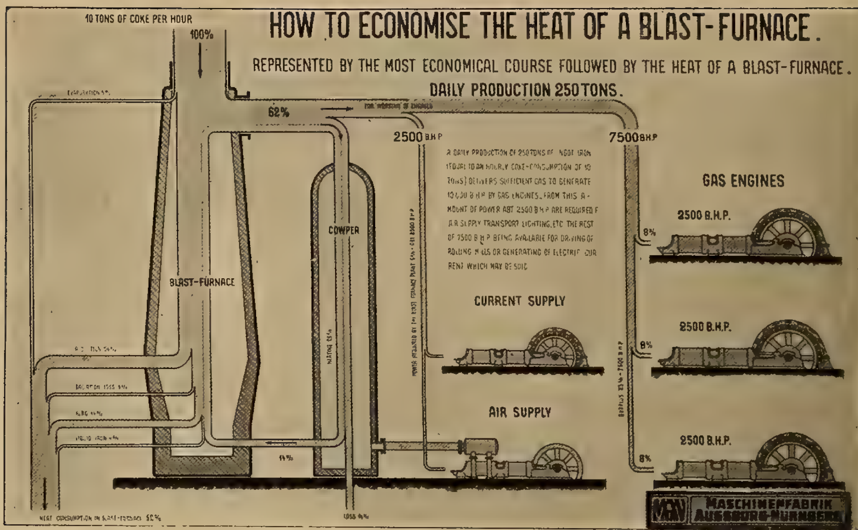


DIAGRAM SHOWING AMOUNT OF GAS AVAILABLE FROM BLAST FURNACES

of the ignition boxes is done in about ten minutes, and for a proper cleaning of the whole engine two days may generally be taken as sufficient when six men are employed. This operation should be performed every six months, although this period has been passed without any apparent effect upon the performance of the engine.

The system of cooling forms an important element in the successful operation of the large gas engine, and this detail has been given especial attention in the Nurnberg engines.

To bring the fresh supply to the hottest points, special pipes are arranged inside the cooling space which sprinkle the fresh water on to the

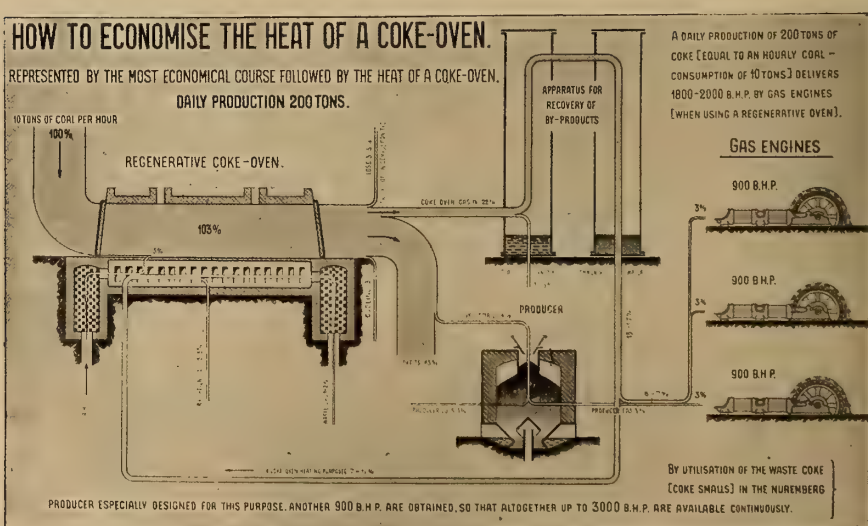


DIAGRAM SHOWING THE AMOUNT OF HEAT THAT IS AVAILABLE FROM A COKE OVEN

pockets of the exhaust ports. The method of cooling the exhaust valve has already been explained. The piston receives its cooling water through the piston rods, which, in their turn, receive the water through a link arrangement connected with the middle cross-head.

The cylinder covers are also effectively supplied with cooling water. The return pipes coming from the different parts are all arranged close to each other on one side of the engine, and pour the waste water into a common tank (see Fig. 14). sure has to be considerably higher, and about 50 pounds to 60 pounds per square inch should be available. Where water of such a pressure is not available, the Nurnberg engine is supplied with a special water pump, driven by an eccentric and rod direct from the crank shaft.

Forced lubrication is adopted practically throughout the whole engine. In the main bearings, connecting rod bearings and main cross-head slide, the flush system is applied. The oil from these parts is delivered from a tank some yards above the engine-

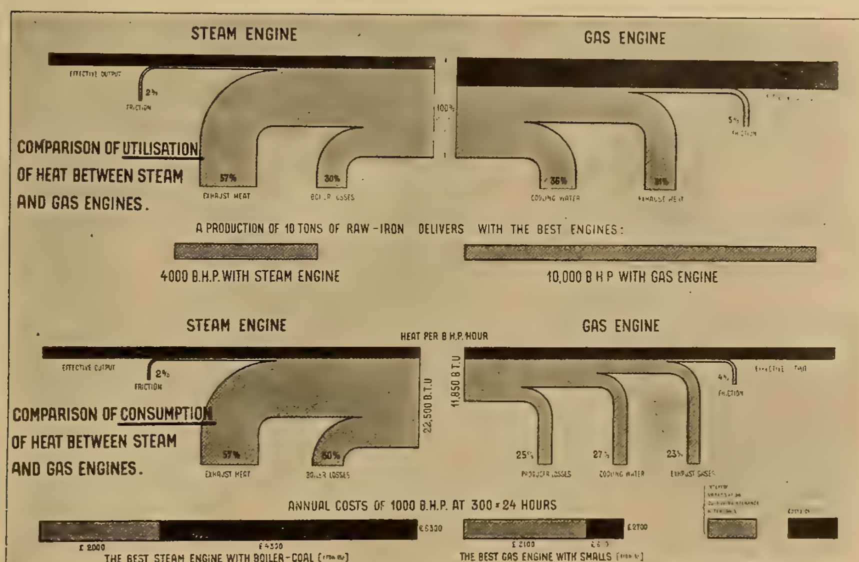


DIAGRAM OF COMPARISON BETWEEN PERFORMANCE OF STEAM ENGINE AND GAS ENGINE

Each return pipe is fitted with a thermometer and a wheel valve, so that the water temperature of each part to be cooled can be independently regulated to the required degree. The opening of one main stop valve brings the whole cooling arrangement into action, and renders it impossible for the opening of a cooling pipe to be forgotten by the carelessness of the engine driver.

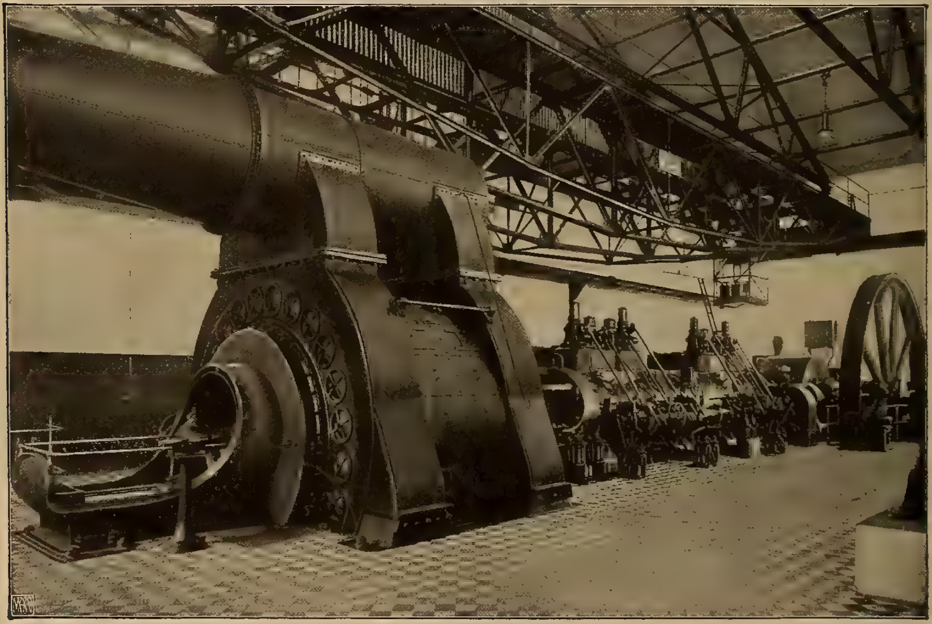
The pressure required for the cylinder and exhaust valve cooling water is about 20 pounds per square inch. For the piston cooling the pres- house floor, to which it is pumped by a pump driven directly from the engine. The oil from the connecting rod bearings and slide collects in the groove of the bed, that from the main bearings in small trays, whence it flows back to a tank underneath the engine-house floor, passes some filtering devices, and is drawn into the pump to start the circulation again.

The following data and information concerning some installations of Nurnberg gas engines will be of interest:

At the Hasper Eisen & Stahlwerke, Westphalia, there are in operation nine engines, totaling 12,750 horse-power, operated by blast-furnace gas. Four of these are blowing engines of 1,250 horse-power each, and five, shown in the illustration, are gas-engine dynamo sets of 1,500 horse-power each, generating three-phase current and operating in parallel without difficulty, notwithstanding sudden and great variations in the load.

in August, 1908, and this is running night and day, the gas engines running parallel with each other, and with a steam engine and exhaust turbine some miles off. A second engine of 2,400 horse-power has since been ordered. The illustration shows the 2,400 horse-power set.

The engine shown at the Brymbo Steel and Ingot Iron Works, 900 horse-power, was started in April, 1907, and has been running uninterruptedly day and night ever since,



BLAST-FURNACE GAS ENGINE OF 1,800 B.H.P. AT THE ROCHLING'SCHE EISEN UND STAHLWERKE, DIEDENHOFEN, GERMANY

The first plant in England in which a Nurnberg gas engine was installed was at the Bargoed colliery of the Powell-Duffryn Steam Coal Company, this consisting of three engines totaling 6,000 horse-power. The first engine developed 1,300 horse-power and was coupled direct to a three-phase alternator of The Electrical Company, Ltd., of London, and has been running since March, 1907. A second engine of 2,400 horse-power, the largest gas engine in the United Kingdom, was started

with the exception of Sundays, using a mixture of coke-oven and blast-furnace gases.

The preceding diagram shows clearly the amount of gas available from a blast furnace for power purposes. A blast-furnace plant having an output of 250 tons of pig-iron per 24 hours requires about 10 tons of coke per hour. From the quantity of heating capacity, which is put into the furnaces by this coke, 60 to 65 per cent. leave the furnace again in the gas. About 28 per cent.

of the heat or 43 per cent. of the gas leaving the furnace is used for heating the blast in the stoves, and the rest is available for power purposes. Generally 8 to 10 per cent. of the heat or 12 to 15 per cent. of the gas is used for driving the gas-blowing engines and for generating electricity for the hoists, lighting and water supply of the furnaces. The power still remaining, about 24 per cent. of the heat, equal to not less than 7,500 horse-power, generated in gas engines, is at our disposal.

Similar conditions prevail in collieries having up-to-date coke-oven plants, with by-products recovery and surplus gas. The diagram shows a coke-oven plant of a production of 200 tons of coke in 24 hours. This quantity is obtained by the coal consumption of 10 tons per hour, which gives, after deducting all losses, a quantity of gas equal to 1,800 to 2,100 horse-power in gas engines. If the coke ashes are utilized in special producers, which are now successfully built by the Nurnberg firm, a further 900 to 1,000 horse-power can be obtained by gas engines giving a total of 3,000 horse-power.

The diagram on page 569 is of interest as showing the comparative utilization of heat between steam and gas engines and also the actual consumption of heat between two engines of the two types.

In general the consumption of the Nurnberg gas engine may be taken at 100 cubic feet of gas per horse-power per hour, while about eight gallons of cooling water of an inlet temperature of 60 degrees Fahrenheit are required. About 3 to 4 per cent. of the cooling water is lost by evaporation. Adding to this 4 per cent. of evaporation, the water required for washing the blast-furnace gas gives a total water consumption of 0.55 to 0.65 gallons per horse-power hour.

Current Topics

AMONG the various transformations which have taken place during the past decade, one of the most interesting is that relating to the general conduct of transatlantic steamships, so far as the cabin passengers are concerned.

In the old days of the sailing ships the navigation of the vessel was the principal thing; passengers were altogether a secondary matter, regarded by many captains as somewhat of a nuisance, and, in any case, as of less importance than cargo. With the development of the passenger steamship, the commercial value of the passenger began to make itself evident, and while the captain still retained his importance as the head of the ship, he felt it incumbent upon himself to be more or less attentive to his passengers, and the "captain's table" became the place of importance, the passengers thronging into the saloon at the sound of bell or trumpet, and claiming the seats at table which they had secured after passing through the initial formalities demanded by the imperious chief steward.

As time passed on, it gradually became evident that the domination of the passenger was impending. The captain has subsided into his proper place as the chief navigating officer, responsible for the conduct of the vessel, but altogether an unimportant element in social life on the ship. In many cases he does not appear at all among the passengers, but occupies his own room on the bridge deck, and attends strictly to business. In the meantime, the ship itself, so far as the passengers are concerned, has assumed its true position as a floating hotel. The passengers engage their rooms as they would at any high-class hostelry on shore; they go to the saloon when they choose, and sit at any place which may be vacant, as they would at any first-class restaurant. The chief steward is to them a headwaiter; their steward for that particular meal is their waiter for the time being; the fact that they happen to be afloat does not enter into the relations which they hold to these people any more than the fact that they are on land brings them into any close relation with the manager of the hotel or the detailed administration of the house at which they may be stopping.

The modern ocean steamship is so safe and speedy that the nature of its structure and operation need not enter appreciably into the daily life of its passengers any more than the conduct of the kitchen or the engine room of a hotel is allowed to appear. The danger of accident is no greater in the one case than in the other; the necessity for the detail of or-

ganization or discipline being pushed into evidence is altogether needless in either case. Thus we see that it is wholly unnecessary for any differences to be made in the conduct of floating and stationary hotels, so far as the guests of the house are concerned. The officers understand that they should subordinate themselves wholly to their functional duties, leaving the passengers to the same freedom which exists in any well-conducted hotel in any place where the entertainment of desirable patrons is the principal object of the business.

It is becoming more and more apparent that the steamship lines which have modified their conduct in accordance with the above methods are those which are acceptable to the best classes of patronage, and it is a matter for congratulation that the older primitive customs pertaining to ocean transport are fading into the past and disappearing from present practice.

PROFESSOR WEIGHTON does some useful work with his experimental engines at the Armstrong College, Newcastle-on-Tyne, and some of his latest tests are just made the subject of a paper by him before the North-East Coast Institution of Engineers and Shipbuilders. Necessarily, tests on a steam engine must not be allowed too much weight when considering the case of another engine; but with suitable mental reservations and the help of experience, test results may be used as a guide-post, if not as a tramrail. What was aimed at in these latest tests was the ascertainment of the effect upon the steam consumption per brake-horse-power of running the engines at varying speeds of revolution, nothing being altered except the resistance against which the engines were working. In itself this appears a simple matter, and would appear to lend itself to the determination of the cylinder losses at different speeds, showing the effects of the duration of exposure upon the rates of condensation of the initial steam. But the matter is not thus simple, for there comes into the problem the throttling effect of the steam ports and passages, and this is the most marked at the highest speeds, and therefore the intention of admitting an equal amount at each stroke of the piston is frustrated, and the reduction of initial condensation which high speed should bring about will tend to be less marked than if the full weight of steam were admitted that is admitted at the lower speeds. As the author says, the late Mr. Willans carried out tests somewhat on these lines; but he worked with an engine of abnormal type such as could never become general, and his results were given per indicated horse-power and did not go deeply into the effects of speed of revolution. The professor's system of testing, however, serves to eliminate the disturbing effect which acts in practice where any change of speed of, say, a marine engine is brought about by variation of boiler pressure. Such tests as he has made could only be made at sea by equipping a ship with a series of resistance plates along its sides or in the shape of a drag anchor astern. The test engines could be worked either with triple or quadruple expansion, according to the arrangement of cylinders whose diameters are 7 inches, 10½ inches, 15½ inches and 23 inches, the 7-inch cylinder being cut out when running as a triple-expansion engine. It was found that the total steam used per hour W could be related to the speed R in revolution per minute, as follows:

For quadruple working, $W = (6.1\ R + 439)$;

For triple working, $W = (7.16\ R + 678)$,

the weight of steam varying as a multiple of the revolutions plus a constant, the constant varying with the type and characteristics of the engine. It may be urged that the con-

stant sums up in itself the effect of cylinder condensation, back pressure, friction, leakage, radiation and such losses as may be said to occur to an engine at no speed. Then the weight of steam per revolution will be:

$$W = \frac{W}{60R} = \frac{6.1R + 439}{60R} = 0.102 + \frac{7.32}{R}$$

for quadruple working, and for triple working similarly $W = 0.119 + \frac{11.3}{R}$

Obviously these figures mean that the steam consumption per revolution diminishes with increase of speed, just as might rationally be expected; and thus far the tests are merely confirmatory of the logic of experience and former tests.

The effect of ports is discussed, and it is remarked that so long as the revolutions rise at a rate faster than the mean pressure falls (as a result of port friction, etc.) the former will increase with the revolutions. There is thus a limit of speed beyond which more power cannot be obtained, but rather less power, unless the boiler pressure is raised sufficiently to overcome resistance. But obviously for every engine at a given boiler pressure there is a limit of speed beyond which no further power can be obtained, and the author believes that this limit of speed is lower than is usually supposed.

DISCUSSION still continues in the *Engineer* on the subject of cylinder condensation and re-evaporation. The leakage theory is advanced with some flourish. It appears to be necessary for the new school to trust practice to fit a mere theory for which there was, after all, little need. The old theory of cylinder condensation, as advanced by Clark and ably expounded by him, certainly required very rapid action of the cooled cylinder walls to account for condensation. Because they cannot understand the rapidity of action the new school say that the missing steam has leaked away. But how do they account for the equally mysterious missing heat when a hundred degrees of superheat disappear before cut-off? Does the superheat go entirely into that portion of steam which mysteriously leaks away? and because a surface condenser only deals with about ten pounds of steam per square foot per hour is it to be granted on the mere *ipse dixit* of the new school that this is proof against the rapid action of the cylinder wall, cooled, as it is, to many hundred or thousand times an hour by the evaporation of water from its surface? The leakage idea is not novel. It was advanced some thirty-four years ago by William McNaught; but that writer did not, if we remember rightly, talk about missing quantities of steam. On the contrary, the filling up of the toe of the indicator diagram, which is now attributed to the re-evaporation of the missing steam, he attributed to leakage past the valve from the steam chest into the cylinder. He had a surplus quantity rather than a missing quantity. But it is to be feared that he did not compare the steam shown by the diagram with the water fed into the boiler. McNaught especially insisted that the expansion curve of the diagram ought to fall below the hyperbola, and so it ought in an ideal adiabatic cylinder, for does not some of the steam condense in the performance of work? But in a tight engine it never does fall below the hyperbola, and because it did not do so McNaught said that the toe of the diagram was "filled up" by leakage past the valve. He had nothing to say of initial condensation—did not seem to have heard of it. He merely looked for an explanation of why the steam-expansion curve was too flat, and so he invoked leakage one way to account for it, while the new theorists demand leakage the other way. Between the two the accepted old theory bids fair to survive.

COMMANDER ROBERT E. PEARY, U. S. N., CIVIL ENGINEER

A BIOGRAPHICAL SKETCH

COMMANDER PEARY is an excellent example of the training and experience of the engineer applied to the work of the explorer, and the result has abundantly proved the effectiveness of such a preparation for such undertakings.

Robert Edwin Peary was born at Cresson, Pa., on May 6, 1856; but in his early boyhood his parents removed to Maine, and he received his primary education in the public schools of Portland, after which he entered Bowdoin College, from which he was graduated in the class of 1877. After leaving college he pursued the study of civil engineering, entering the service of the United States Coast and Geodetic Survey at Washington as draughtsman, and in 1881 he passed the examination sucesssfully and became a civil engineer in the United States Naval service.

The plans for an isthmian canal were then under discussion in connection with the choice of possible routes, and Mr. Peary was appointed an assistant engineer in connection with the government surveys for the proposed Nicaragua route, serving in this capacity from 1884 to 1885, and being made chief engineer in charge of these surveys from 1887 to 1888. In connection with this work he devised a form of rolling gate for use in the locks of the proposed canal.

Even during his college period the subject of Arctic exploration had strong attractions for young Peary, and when he obtained a leave of absence from his work on the Nicaragua surveys, in 1886, he spent the time in making a reconnaissance of the inland ice cap of Greenland, thus beginning the systematic method of gathering accurate data which has marked the application of engineering methods to Arctic exploration. The charting work on this expedition carried him to a point east of Disko Bay, in latitude 70 degrees north.

In 1891 came the opportunity for the conduct of the Arctic expedition of the Philadelphia Academy of Natural Sciences. This included the use of the ship *Kite*, and, sailing from New York, Peary established headquarters in McCormick Bay, on the western coast of Greenland, whence he made sledge excursions along Whale Sound, Inglefield Gulf and Humboldt Glacier, these showing the convergence of the eastern and western coasts of Greenland. Although his leg was broken in the course of this work, he persisted, reaching Independence Bay — so named by him—at a latitude of 31 degrees 37 minutes north, also discovering and naming Melville Land and Heilprin Land, these lying north of Greenland and being separated from it by Peary Channel. This trip thus proved the insularity of Greenland, a discovery for which Peary received the Cullum medal of the American Geographical Society, the Patron's medal of the Royal Geographical Society of London, and the medal of the Royal Scottish Geographical Society of Edinburgh. This trip also included explorations of Inglefield Gulf and plans for the accumulation of supplies of stores along the fringe of the inland ice.

Mr. Peary returned from this trip in September, 1892; but in the following year he made another northern voyage, upon which he made a

thorough study of the Eskimos of Northern Greenland, called the Arctic Highlanders, a little tribe of about 300 souls, living in the territory extending from Cape York to Etah, a people whose friendly associations have done much to aid in Arctic exploration. It was on this trip that Mr. Peary discovered the meteorites heard of by Ross as the "Iron Mountain," the largest of which has since been transferred to the American Museum of Natural History in New York, this having been effected during his summer voyage of 1897.

In 1898 Commander Peary undertook another expedition under the auspices of the Peary Arctic Club, of New York City, during which he rounded the northern extremity of the Greenland Archipelago and reached a latitude of 84 degrees 17 minutes, naming the northernmost cape, at 83 degrees 39 minutes, Cape Morris K. Jesup, after the president of the American Museum of Natural History.

Peary's first dash for the North Pole was made in the summer of 1905 with the steamer *Roosevelt,* built especially for the purpose; and on this trip, after enduring great hardships, he succeeded in reaching a latitude of 87 degrees 6 minutes, the farthest north which had been attained up to that time. He brought his ship back with him, and made his second attempt, again in the *Roosevelt,* leaving New York in July, 1908, and on September 7, 1909, he sent word from Labrador that he had reached the Pole on April 6, 1909.

Peary's success has been largely due to the fact that he attacked the problem in an engineering way, the whole trip being planned out on the basis of large experience, involving the establishment of bases of supplies and utilizing the co-operation of the friendly natives.

Commander Peary has been awarded, in addition to the medals already mentioned, the Kane gold medal of the Philadelphia Geographical Society and the Daly gold medal of the American Geographical Society, of which society he was president in 1903. He is a member of the American Society of Civil Engineers, honorary vice-president of the Alaska Geographical Society, honorary member of the Philadelphia Geographical Society and of the American Alpine Club. He is a contributor to various magazines, and author of "Northward Over the Great Ice."

Manufacturing News

An Improved Vacuum Cleaner

IT is now generally recognized that the proper way to get rid of dirt is not to stir it up, but to remove it bodily.

IMPROVED VACUUM CLEANER, MANUFACTURED BY THE PORTABLE AIR SUCTION CLEANER COMPANY

This method has long been employed for objectionable matter in particles of such size that they can readily be collected, but it is only recently that suitable devices have been provided for the complete removal of that most objectionable form of dirt known as dust; containing, in a state of fine subdivision, all kinds of unclean and injurious matter, disease germs, irritant particles, and similar substances.

By the use of suction, however, this form of dirt can be removed most effectively and completely, and in the illustration of the Aspirator, shown herewith, the construction of mechanism for vacuum cleaning, available at any point, may be seen in detail.

The Aspirator, manufactured by the Portable Air Suction Cleaner Company, of 313 West Fifteenth street, New York City, is a particularly high-class machine, and at the same time one of simple construction. A battery of suction bellows is operated by an electric motor taking current from a lighting socket, drawing the air carrying the dust through the cleaning tool and hose into the dust box; an especially efficient filter preventing any of the dirt from reaching the bellows or other working parts. The whole is enclosed in a handsome cabinet, so that it may be allowed to remain in any room without detracting from the appearance of its surroundings, while it

may easily be taken to any part of the house or building for use.

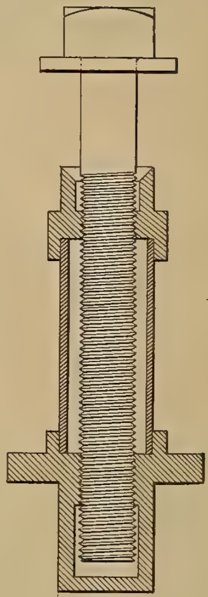
The portable machine has important advantages over the built-in cleaner, or one operated from a wagon, apart from the reduction in first cost, since the force of suction is adapted for the immediate locality and does not have to be so powerful as to reach distant points, and thus be too strong for curtains, hangings and other delicate articles.

The Aspirator, while perfectly adapted for handsome dwellings, hotels, apartments, etc., is entirely available for use in manufacturing establishments, and with a machine at hand there is no reason why any part of a factory, drafting room, office, or workroom should be allowed to remain a harbor for dust or dirt. The Aspirator is in use in many of the palaces and hotels of Europe, as well as in theatres, on steamship and railway lines, and in industrial establishments, and has fully demonstrated its claim to be a thoroughly well-designed and constructed machine for the removal of dust and dirt by suction.

An Anchor Bolt for Reinforced Concrete

ONE of the features connected with the use of reinforced concrete in building construction lies in the importance of a convenient and effective means for securing other portions of the work to the concrete, or of subsequently attaching machinery or floors to foundations. In some cases the connections are made by means of bolts solidly imbedded in the concrete, but we illustrate herewith an improved method employed by the C. A. Bolt Company, of New York, which offers many advantages. As shown in the illustration, this device consists of two parts, the belt proper and the socket into which it enters, this latter being imbedded in the concrete.

The socket is composed of two castings, connected by a piece of wrought-iron pipe, the parts being cast together, thus insuring water-tight joints. A long tap is passed through the socket, so that the bolt is held at both points. By this construction the lower casting takes up the strain in tension, while the upper one resists any lateral thrust. The proportions of the parts are such that the bolt itself will fail before the threads in the socket will strip or the socket be pulled out.



IMPROVED ANCHOR BOLT FOR CONCRETE.
C. A. BOLT COMPANY, NEW YORK.

With this device it is possible to imbed the sockets in the concrete at the time the work is done, while the bolts may be entered or removed later as may be desired, while the rigidity and strength of the solidly-imbedded bolt are at the same time secured. The form of the upper casting, acting as a cutting edge, forces itself into the wood when wooden objects are anchored, forming a water-tight seal, while for hard surfaces this cutting edge can be placed flush with the concrete surface. This form of anchor bolt thus removes one of the objections hitherto made to the use of concrete and enables entirely satisfactory connections to be made.

Water-Tube Boilers in the Navy

IN connection with the construction of the United States battleship *Florida* at the New York Navy Yard, the subject of the use of water-tube boilers has come up for settlement. It is to be hoped that boilers of this type and of American design will be adopted, both because of the adaptability of the system and its lower cost and less weight as compared with the older forms of marine boiler. Certainly the latest type of battleship should be equipped with the most modern form of American marine boiler.

Reversible Drum Controllers for Alternating-Current Motors

THESE controllers, which are a new product of the Cutler-Hammer Manufacturing Company, Milwaukee, Wis., are designed especially for use with two or three-phase slip-ring type induction motors operating cranes, hoists and other classes of machinery which require frequent starting and stopping. Both drum and resistance are rated for intermittent duty not exceeding 150 per cent. of the motor rating for both primary and secondary circuits, and are designed to reduce the motor speed 50 per cent. under average load conditions. Where service conditions are exceptionally severe, or where there are certain special specifications to be met, the standard controller may not be suitable. Prices on controllers to meet special conditions will be furnished on application.

The contacts of the controller for handling the secondary resistance have a certain maximum capacity and a certain spacing, so that there is a limitation to be placed on both the secondary current and voltage. The normal full load secondary current or the voltage between collector rings with rotor stationary must not exceed the values given in the table below for the corresponding drum sizes:

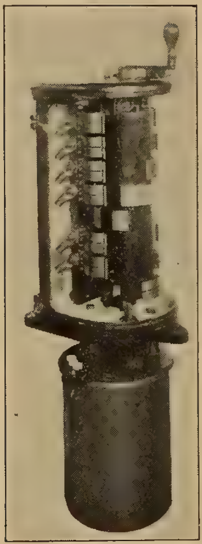
Type drum	Normal rotor current	Maximum rotor voltage
A	40	150
B	80	280
C	150	280
D	250	280
G	400	400

Where the rotor current or voltage of a motor exceeds the above values it will be necessary to use another drum, or make other special arrangements. For motors of 10 to 30 horse-power the rotor current is often beyond the capacity of the type B drum, so that prices are listed for those sizes using the type C drum as an alternative.

The drums consist of a three-pole primary, combined line and reverse switch, and a cylinder for controlling the secondary starting and regulating resistance, mounted on the controller shaft and driven directly by the operating lever. For all sizes of drums the secondary resistance controller is of open construction. For the types A, B and C drums the primary switch is also of open construction, but for the types D and G drums the primary switch is immersed in oil. The A, B and C drums are arranged for wall mounting, but the D and G

TYPE A, B AND C CONTROLLER. THE CUTLER-HAMMER MFG. CO., MILWAUKEE, WIS.

drums are for floor mounting, in order to provide properly for the oil tank containing the primary switch. The installation of the latter drums should provide space for the removal of the oil tank for connecting and inspection. The drums are constructed of the best materials throughout. All contacts and brushes are made of hard-drawn copper, and are easily and cheaply renewed. The contact segments are firmly mounted on a metal cylinder, which remains perfectly true under all climatic conditions. The oil tanks



TYPF D AND G CONTROLLER. CUTLER - HAMMER MFG. CO., MILWAUKEE, WIS.

for the types D and G drums are of seamless steel and will not leak. These tanks should be kept full of a clear mineral oil. Machine oil must not be used.

Resistance is provided in each of the three phases of the rotor circuit, mounted in comparatively small frames for convenient installation. Except for the small sizes, the resistance is of the cast-metal grid type. The resistance is as compact as possible consistent with ample capacity for intermittent regulating duty.

The following information is essential to the satisfactory filling of orders for these controllers:

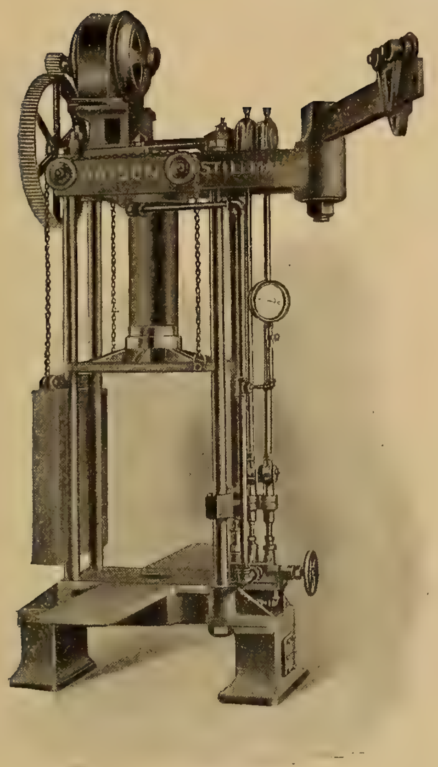
1. Horse-power of motor.
2. Voltage of circuit.
3. Whether circuit is two-phase or three-phase.
4. Normal full load rotor current.
5. Voltage between collector rings with rotor stationary.
6. General operating conditions; character of hoist or machine; and special specifications that must be met.

A New Reversed Cylinder Press

THE Watson-Stillman Company has just introduced a new reversed cylinder forcing press, which should prove a handy tool for pressing bearings and for miscellaneous work. As will be seen from the illustration, a crane bracket and beam extending from one end enables the operator to swing a heavy piece of work onto bracket shelves extending out from each side of the bottom platen. These shelves, 30 inches long by 12 inches wide, are detachable, can be lifted off on jobs where they would be in the way, and are sufficiently strong to support any work that will go into the machine. They will be appreciated by those who have had to push castings or parts into place on the ordinary small platen.

The motor, mounted upon pedestals on top of the press, drives the pump shaft through single reduction gearing. A hand or belted drive is furnished if desired instead of the motor. On the other end of the pump shaft are two eccentrics, each driving one of the pistons of a ¾-inch by 2-inch twin pump, for which the pedestal legs act as reservoirs.

The operating valve is of the single screw stem type, and connected to release the pressure from the work when opened and start the ram down when closed. It will not retain the pressure unless the motor is stopped or the liquid driven through the



NEW REVERSED CYLINDER PRESS. THE WATSON-STILLMAN COMPANY, NEW YORK.

safety valve. Other types of valves may be substituted to meet special conditions. A gauge is furnished, to read in tons or pounds per square inch, as desired.

Literature descriptive of this and many other assembling presses may be obtained by addressing the manufacturers, the Watson-Stillman Company, 50 Church street, New York.

Dean Bros. Duplex, Double-Acting, Belt-Driven Pump

THIS pump is duplex, and has two double-acting cylinders. As the cranks are quartering, there are four discharges per revolution of the crank, delivering a steady, continuous flow.

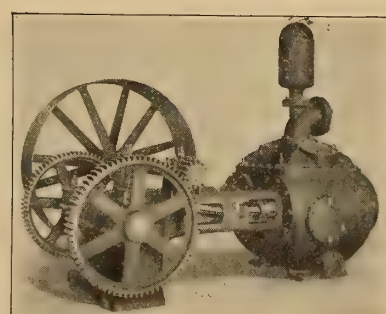
It is driven by gears at each end of the crankshaft. No power is transmitted from one crank to the other, and torsion strains between the cranks are eliminated.

Discharge valves are above the pistons and the suction valves below the pistons, all accessible through suitable hand-hole openings. Access to pistons is by removing heads on outer end of pump cylinders.

The valve seats, springs and stems are bronze. The valves are rubber, flat-disc type. The valve seats screw into the valve decks, and are, therefore, removable. Access to the pistons can be had by removing the cylinder heads.

It possesses no experimental features. The materials used and the design are the result of years of experience with this class of machinery. Nothing is omitted that would add to its durability, reliability or efficiency.

It may be driven by belt, electric motor or other power. All the gearing is machine-cut. The crankshafts are steel. The pinion shafts are



DUPLEX, DOUBLE-ACTING, BELT-DRIVEN PUMP. DEAN BROS., INDIANAPOLIS, IND.

steel. The connecting-rods are steel, with brasses at crank and cross head. The cross head works in bored guides. Crankshafts have unusually large main and crank-pin bearings. To illustrate the size of these bearings, a pump, with 4-inch diameter cylinders and 10-inch stroke, must have the main crank bearings 3 inches diameter and 5 inches long.

These machines are self-contained. They are subjected to a running test in the shops corresponding, as nearly as possible, to service conditions. Manufactured by Dean Bros. Steam Pump Works, Indianapolis, Ind.

News Items

The Buckeye Engine Company, Salem, Ohio, announce the appointment of Mr. Louis Bendit, Assoc. Am. Soc. M. E., Kansas City sales manager, 504 New York Life building, and Mr. J. R. Detweiler, district manager, Wichita, Kan., 505 Barnes building. The Buckeye Engine Company build gas engines suitable for natural or producer gas in various sizes up to 5,000 horse-power units, and steam engines in simple, tandem or cross compound up to 8,000 horse-power units. Through a gas producer bituminous or anthracite coal, lignite, coke, charcoal or crude oil can economically be utilized, and with a Buckeye gas engine results can be obtained that cannot be approached by the most refined steam plants.

The American Society of Mechanical Engineers will hold its spring meeting in Washington, D. C., May 4-7. Professional sessions will be held, at which papers on the conveying of materials, gas-power engineering, steam turbines, the specific volume of saturated steam, oil-well pumping, and various other subjects will be discussed.

At the reception, which will be held in the New Willard Hotel, an address of welcome will be made by the Hon. B. F. Macfarland, president of the Board of District Commissioners, with a response by Mr. Jesse M. Smith, president of the society.

During the convention President Taft will hold a reception for the members at the White House. The War Department will give a special exhibition drill of the United States troops at Fort Myer, to which the members and guests will be invited. At the same time, if the conditions are favourable, an ascension of a dirigible balloon will be made, and probably also that of an aeroplane.

An address will be given by Rear-Admiral Melville, Ret'd, past-president of the society, and former Engineer-in-Chief of the Navy, the subject being "The Engineer in the Navy." This evening will be made the occasion for the presentation to the National Gallery of a portrait of Rear-Admiral Melville, presented by friends and admirers. It will be received for the National Gallery by Dr. C. D. Walcott, secretary of the Smithsonian Institution.

F. H. Newell, director of the Reclamation Service, will deliver an illustrated address on "Home Making in the Arid Regions." Trips will be made to various points of interest about the city, and a number of pleasurable excursions have been planned.

An interesting periodical entitled "The Penberthy Engineer and Fireman" is published by the Penberthy Injector Company. It has a circulation of 10,000 copies each month, has over 3,500 paid subscribers, and is an interesting periodical throughout devoted to engineering subjects and such other matter which is of timely interest.

Another evidence that business is on the increase is the announcement of the Royal Typewriter Company that they will occupy their own building, 364-6 Broadway, New York, about the 20th of April.

They will occupy the largest and handsomest typewriter headquarters in the world, and will be prepared to take care of all typewriter wants in every department. Special attention will be given to the Stenographic Bureau, which will furnish, without charge for the service, competent stenographers and office help to their numerous patrons.

The public is cordially invited to call and inspect their magnificent store and see another step in the wonderful growth of this company.

A high-grade machine at $65 instead of the custom-habit price of $100, has solved the typewriter problem, and popular opinion is now supporting the Royal, even with competitors meeting this price.

THE LATEST CATALOGUES

Direct Current Instruments

THE GENERAL ELECTRIC COMPANY, Schenectady, N. Y. Bulletin No. 4,643 illustrates and describes two lines of switchboard instruments, Types D-2 and D-3. The difference in the two types is mainly in the size of the instruments. All are circular in shape, are of strictly first-class construction, have prominent, extremely legible and well-lighted scales, and large needles. The bulletin contains illustrations of the scales of the various instruments, and also catalogue numbers and prices of the instruments.

Engines and Boilers

ATLAS ENGINE WORKS, Indianapolis, Ind. In the 1909 edition of their general catalogue the manufacturers have contented themselves with giving an illustration and a simple description of each engine, together with a statement of the usual range of sizes. Recognizing the growing tendency of using internal-combustion engines for small powers, they have introduced in this issue a line of gas and gasoline engines.

Economizers

B. F. STURTEVANT COMPANY, Hyde Park, Mass. Two pamphlets treating on the use of economizers in steel and in textile mills, respectively. They are profusely illustrated, and many instances are cited where the Sturtevant economizers have been successfully installed.

Riveters

CHESTER B. ALBREE IRON WORKS, Allegheny, Pa. This company have just gotten out their new catalogue No. 10 descriptive of their "Pittsburg" riveting machines and special types of pneumatic compression riveters. Attention should be called to the tables on rivets and riveting in the back of the catalogue, which have been enlarged and revised.

Air Compressors

INGERSOLL-RAND COMPANY, New York. Catalogue No. EE-36 describes the various types of small power-driven air and gas compressors manufactured by this company.

Pumps

DEAN BROS. STEAM PUMP WORKS, Indianapolis, Ind. Catalogue No. 72 issued by this company describes and illustrates the various styles of hydraulic pressure pumps manufactured by them. Tables giving the standard dimensions of the different sizes that are made are also given.

Friction Clutches

DODGE MANUFACTURING COMPANY, Mishawaka, Ind. Bulletin 116 gives an interesting description of the Dodge split clutch, its advantages and applications. The bulletin is nicely illustrated, and sectional views showing the working parts of the pulley are also inserted.

HILL CLUTCH COMPANY, Cleveland, Ohio. An interesting booklet, which is a reprint of a paper presented before the last annual meeting of the American Society of Mechanical Engineers, has just been published by this company. The subject of it is: Tests of Friction Clutches for Power Transmission, by Prof. R. G. Dukes. Anybody interested in this subject can obtain a copy of the paper by applying to the company.

Grinding Wheels

NORTON COMPANY, Worcester, Mass. The 1909 catalogue issued by this company contains an extensive list of grinding wheels and machinery. Among the most important "Norton Products" may be mentioned alundum grinding wheels, grinding machinery, glass-cutting wheels, India oil stones, razor hones, scythe stones, and rubbing and sharpening stones.

Roofing

THE BARRETT MANUFACTURING COMPANY, New York. A handsome folder giving views of the great textile mills at Lowell, Mass. The total roof area of these mills is 1,800,000 square feet. Only one form of roof covering is used on the permanent buildings in these plants, and that is coal-tar pitch, felt and gravel laid along the lines of "the Barrett specification."

Mill Motors

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, Pittsburg, Pa. Circular No. 1,164, just issued by this company, is devoted to the description of type MS mill motors for polyphase alternating current circuits. The essential features of the first squirrel-cage induction motor designed especially for mill service, where all the machinery must be as nearly as possible proof against failure, are pointed out.

Machine Tools

THE GARVIN MACHINE COMPANY, New York, N. Y. Edition "D" Catalogue, printed in English, German and French, describing profiling machines, both "Wessona" and belt-driven, vertical spindle milling machines, duplex milling machine, universal cutter and tool grinders, tapping machines, etc., manufactured by this company.

Thermit Repairs

GOLDSCHMIDT THERMIT COMPANY, 90 West Street, New York. An interesting booklet entitled "Thermit Repairs," giving many examples of the many and wonderful repairs that are possible by means of this process.

Transformers

THE GENERAL ELECTRIC COMPANY, Schenectady, N. Y. Bulletin No. 4,640 is devoted to large transformers, in which are given some of the more important points regarding the relative merits of the different types of large transformers manufactured by this company. This publication has to do with the oil-cooled, water-cooled and air blast transformers of large capacity, and contains illustrations of both the exterior and interior of various types. It contains also information intended to assist a customer in determining whether air blast or water-cooled transformers will be more suitable for a given installation.

Coal-handling Machinery

THE JEFFREY MANUFACTURING COMPANY, Columbus, Ohio. Catalogue 32-A, illustrating coal and ashes-handling machinery for power plants. A great number of typical installations are described and illustrated.

Recording Gauges

THE BRISTOL COMPANY, Waterbury, Conn. Bulletin No. 102, just issued, contains a partial list of Bristol's recording gauges for pressure and vacuum.

Shapers

GOULD & EBERHARDT, Newark, N. J. The new catalogue of this company describes their latest improved Eberhardt's patent "High Duty" shapers. Many illustrations are given, and the various special attachments which they furnish are also described.

Steam Hammers

NILES - BEMENT - POND COMPANY, New York, N. Y. Catalogue entitled "Bement Hammers," describing and illustrating the single and double-frame hammers, double-frame steel tilting hammers, steam drop hammers and board drop hammers made by this company.

Gas Engines

DUBOIS IRON WORKS, Dubois, Pa. New 1909 Catalogue describing and illustrating Dubois single-cylinder tandem and twin tandem engines arranged to operate on natural, illuminating and producer gas.

Book News

Entropy

The Temperature-Entropy Diagram. By Charles W. Berry, assistant professor of mechanical engineering in the Massachusetts Institute of Technology. Size, 5 x 7½ inches. 299 pages, with 109 illustrations. New York: John Wiley & Sons. Price, $2.

This is the second and revised edition of the Temperature-Entropy Diagram. A more extended application of the principles of the $\tau\phi$ analysis to advanced problems of thermodynamics has been made than was possible in the limited scope of the previous edition. The chapter on the Flow of Fluids has been entirely rewritten, and treats at length various irreversible processes. A graphical method of projecting from the p v— into the $\tau\phi$ plane has been elaborated for perfect gases and its application illustrated in the chapter on Hot-air Engines and Gas Engines. The various factors affecting the cylinder efficiency of both gas and steam engines have been thoroughly discussed. One chapter has been devoted to the thermodynamics of mixtures of gases and vapours and another to the description and use of Mollier's total energy-entropy diagram.

Mining

Mining Methods in Europe. By Lucius W. Mayer, E. M. Size, 6 x 9 inches. 169 pages, with 92 illustrations. New York: Hill Publishing Company. Price, $2.50.

The basis of this book is a report which Mr. Mayer made for a large American mining company of the advanced European methods. The volume describes the more or less distinct and often extraordinary systems of mining practised in various countries of Europe. Its presentation, by an American, to those interested in mining follows considerable travel abroad, consequent to a thorough study of American and European literature treating on the subject of mining methods.

There is hardly a feature in the art of mining on which more depends than the method of underground attack, and this work was incited by the apparent lack of literature on the subject. To be sure, there is an unfortunate scarcity of mining literature in general, and while the technical journals serve the best purposes to-day in this direction, even therein is noted a marked absence of descriptive matter detailing the general subject of ground-breaking.

Abroad there is but little intercourse between mining engineers of the various countries. Indeed, it appears practices in one land are often carried on without the cognizance of those immediately across the line. It is, therefore, anticipated that this book ought to be of value and interest abroad as well as in this country.

Electrical Engineering

General Lectures on Electrical Engineering. By Charles Proteus Steinmetz. A. M., Ph.D., consulting engineer of the General Electric Company, professor of electrical engineering in Union University, past president A. I. E. E. Size, 6 x 9 inches. 284 pages. Schenectady, N. Y.: Robson & Adee. Price, $2.

This book contains a series of lectures delivered by Professor Steinmetz, under the auspices of Union University, Schenectady, N. Y., in the winter of 1907-8, to a class of younger engineers, consisting mainly of college graduates. The subjects were treated in such a simple and intelligent manner that when the lectures were edited it was found possible to avoid the use of mathematics altogether, and so make the lectures equally available to that large class of engineers who do not care for mathematics, or are not familiar with them, without in any way decreasing their value for the college-trained engineer.

The lectures give a broad review of the entire field of electrical power generation, transmission, distribution, control and use, showing the close relation and dependence upon each other of all the factors of the problem.

The Equalization of Energy

IN nearly every method utilized for the generation of power it appears that the effort is exerted at intervals, and that the result must be equalized in some way if a continuous action is to be secured. This is seen in the case of water-power, in which the varying flow of a stream is accumulated in the mill pond or reservoir formed by the construction of a dam, thus averaging the inequalities and permitting a practically uniform supply to be obtained.

Other and similar methods appear in the different types of accumulators, hydraulic, electrical and thermal, which have been devised to convert successive impulses or unequal discharges into continuous effects.

Similar irregularities at the receiving end have to be considered, and there are few systems for the utilization of power which do not have to take into account the varying demands for power. Every variation of the load in a power plant, whether hydraulic or steam, throws a corresponding variation upon the entire circuit, and this must be absorbed and equalized by some form of storage, returning at periods of deficiency the excess of some previous accumulation.

In many cases this system of storage and supply is evident and obvious, as in the example of the mill pond, already cited; but in other instances it is not so apparent. We realize that a pile of coal represents stored value, both as money and as mechanical energy, and we understand that when it is burned under a boiler its latent energy reappears in a sensible form in the steam which is generated; but the action of the coal-storage system as an equalizer of energy is not quite so apparent as in the case of the reservoir.

At the same time the coal pile, whether out of doors or in the elevated bin, is a reservoir of stored energy, just as much as is the case with the reservoir of water. In the latter case it is the action of gravity upon the mass of liquid, capable of conversion into sensible energy by being permitted to fall through a given distance, which enables power to be developed; in the former case it is the stored energy of the sun contained in the coal, which can be released and converted into power. In both cases the motor is only the intermediate agent for conversion, and the real source of power is behind it.

These are fundamental principles, but in connection with their practical execution there are constructive details which may well form subjects for consideration. Fuel, such as coal, not having the fluidity of water, requires the use of properly designed mechanism in order that it may be handled properly. The reservoirs in which it is contained, whether of timber, metal or reinforced concrete, should be designed with proper reference to the nature of the material, the pressure which it may exert, and the wear and tear which its action may cause. Its movement should be effected and directed by suitable conveyors, chutes and valves, and the entire arrangement should be in accordance with well-determined results of extended experience in the handling of such materials. When this is done, the storage of coal represents the equalization of energy as truly and effectively as does the volume of water in the elevated reservoir of a hydraulic plant, enabling the continuous movement of the conversion of latent energy into mechanical power to be effected independently of irregularities in supply, and in accordance with the inequalities in the demand of the mechanism of utilization.

When coal is thus stored it becomes almost as manageable a fuel as gas, since it is held in a reservoir from which a supply can be drawn as needed, and delivered to the point where it is to be converted into mechanical power, the response being almost as effective in both cases.

The Transmission of Power

ONE of the earliest developments of mechanical engineering, specifically so called, was that relating to the transmission of power. The old-time millwright constructed his wooden shafting, his mortise cog-wheels and his heavy pillow-blocks in the places where they were to be used, often working out the various parts by hand to suit the location and rarely executing two jobs alike.

After a while there began to appear the manufacturer of iron shafting, and the older text-books contained examples of cast-iron shafts, some of them ribbed and flanged, and all of them now presenting an archaic appearance, although they once represented the standard practice in power transmission. When the iron mills began to supply round-rolled iron to standard dimensions the makers of transmission machinery saw how effectively this material was adapted to the manufacture of shafting, and thus a standard product entered the market and the way for the development of interchangeable equipment was made clear.

The advent of commercial shafting made possible the manufacture of pulleys, hangers, couplings and other elements of power transmission. The ancient plan of selling such material by weight was replaced by the more rational system of separate prices for the different articles, and thus gradually the business of manufacturing and handling transmission machinery was placed upon a commercial basis.

When the wooden split pulley, with its accompanying system of bushings, was devised in 1876 by the late Wallace H. Dodge, it became possible to supply pulleys, both for belting and for rope driving, from a general stock, without requiring the delay formerly necessary for boring to the size of the special shaft under consideration, the split feature also making it practicable to place a pulley at any point without disturbing other pieces on the same shaft. This latter feature is one which had often been considered before, but it had not been made a standard commercial matter.

In the meantime, there had appeared a general advance in the development of power transmission. The introduction of electrical driving modified the whole operation for many purposes; but it is now fully realized that the two systems are to grow and prosper together, and that each has its field and proper place. Higher rotative speeds have come into use, both for line shafting, countershafts and for the machine tools themselves; while the possibilities of rope-driving have broadened the scope of this useful method. The increasing attention now being given to the care and right use of belting is another indication of the development of scientific methods of power transmission in the shop.

As a consequence of all this progress it is becoming increasingly evident that the latest and most economical results in power transmission and machine driving can be secured only by utilizing the abilities of specialists in this particular department of mechanical engineering. The method which is right for one situation may be distinctly inferior in another case, while a problem which seems new and troublesome to the general engineer may, in fact, be almost a repetition of some precedent well known to the specialist.

In many cases the question of first cost is secondary to the continual costs involved in operation, taking into account friction losses, maintenance expenses, overload capacity and immunity from disastrous breakdowns. As in nearly every engineering question, the wise method is to consider a transmission problem as a whole, taking advantage of the information and experience of the man who has made a specialty of the subject, thus profiting by both the failures and the successes of those who have "been there before."

The Progress of Invention

IN the course of the development of mechanical appliances the student of engineering finds some interesting examples of the manner in which the evolution theory acts upon inanimate as well as living objects, and he sees how the principle of natural selection has governed the production of many useful appliances.

Usually the successive improvements which have appeared in the development of apparatus for any specified purpose have been made by different individuals, in widely separated localities; but in some cases the continual experience of a limited number of men, sometimes in connection with the work of a single establishment, is concentrated upon the development of a special appliance, with remarkable consequences.

A marked example of the manner in which such a mechanical evolution has occurred is seen in the case of the chain block, as used for hoisting loads by human effort, this machine being a most useful application of mechanical ingenuity to the extension of manual labour.

The first chain block to be practically and commercially developed was the well-known differential hoist, invented by Thomas A. Weston more than fifty years ago and manufactured by the Yale & Towne Manufacturing Company, by whom it is still made and widely distributed. This invention, marked by extreme simplicity and great convenience, met with wide approval, and is as popular to-day as ever for applications to which it is adapted.

For many years the differential block was accepted as standard, but with the experience thus gained it became apparent that there were conditions which could better be met by improvements and by extension of the capacity and efficiency of the machine. Under such conditions chain blocks involving somewhat greater mechanical complexity began to form the subjects of experiment, such types including the use of the worm and worm-wheel as reduction gearing, the outcome of this demand being the so-called Duplex block, at once more highly organized and more efficient than the differential block.

Already the influence of environment was being felt, and the result appeared in the extension of the apparatus to meet the varied requirements.

The demand for hoisting appliances of still higher efficiency persisted, however, and the law of evolution continued to work out its natural results. In order that both higher efficiencies and greater capacities might be realized, it was necessary that every cause for unnecessary resistance be eliminated; and, this problem being set, the solution was worked out to its successful conclusion by the production of the triplex block, a machine due both to the effort of Mr. Weston, the inventor of the original differential chain block, and to the resources of the manufacturing establishment by which the differential block had been so effectively produced.

The course of the evolution which has thus been effected may be briefly traced; it includes the original production of a chain hoist by which one man could lift a thousand pounds, and which would hold the load sustained at any point; it passes to the development of a screw hoist of materially higher efficiency and much greater capacity; and it stands to-day with these two types, maintaining their commercial position, but far excelled by a spur-gear hoist, the Triplex, by which a man can handle several tons with an efficiency of 80 per cent, and which enables several men to exert their united effort without excessive labour to raise as much as 20 tons.

As an interesting illustration of the work of the engineer applied "to the use and convenience of man" this record may well be considered as a chapter in mechanical evolution.

Locomotive Cranes

ONE of the first ideas of hard work was that associated with the digging of the earth and the transportation of the sand, rock, gravel or other material thus rendered available. To-day there is probably no operation more effectively performed by machinery than this same process of moving material. Probably the hauling of the loosened earth was first accomplished by power, human effort being replaced by that of horses, oxen or other animals, and then most effectively by the steam railroad; but long after the dump car was in use for hauling dirt the excavating was still effected by human labour, the pick and shovel being the simple tools employed.

The evolution of the crane, for hoisting and handling large pieces in the machine shop and foundry, is well known; and the early machines, built mostly of wood, with hand-operated winches, have been replaced by hand and power cranes, which compare most favourably in design and construction with the machine tools which they serve so effectively. Especially since the general introduction of electric power it has been found practicable to perform most of the functions involved in handling materials by power, and thus greatly increase the capacity and speed of the machinery, while at the same time lowering the cost.

Among the machines thus developed the locomotive crane has taken an important position, bringing, as it does, the advantages of the power crane to out-door work and greatly extending its capabilities. Broadly, the locomotive crane is a type; it is the combination of a steam boiler and engine, or of an electric motor, with a crane capable of handling heavy loads or of carrying a grab bucket, the whole being mounted on wheels and capable of propelling itself along the tracks of a railway.

This means that the work which was formerly done almost entirely by human labour is now performed by a machine which, to the observer, seems to be possessed of almost human intelligence, coupled with the enormously increased capacity added by the extent to which it utilizes mechanical power.

The applications of the locomotive crane are so many and varied that it is impossible to enumerate them, but they are to a large extent governed by the location and general character of the business. The ordinary crane, with hanging block and hook, can be used for handling anything to which it can be attached, employing slings or other convenient means, or it may be provided with a lifting magnet for use in lifting iron articles of almost any form. If there is added some one of the various forms of self-filling buckets, such a crane becomes adapted for handling loose material, such as coal, coke, gravel, etc., and thus any point to which rails can be run become available for the work of the machine.

The locomotive crane finds a most effective field in the yards of large manufacturing establishments, where the loading and unloading of cars can be rapidly effected, and in many cases it may be sent to the extremity of a track to pick up material and deliver it to a car, either for shipment or for delivery into the works with a minimum of cost and time.

In railway wrecking or construction work the locomotive crane has become an essential tool, and it is by the use of powerful machines of this class that the débris of a wreck is removed and traffic reopened; while in the operations of track-laying and roadbed construction such cranes are most effectively employed.

With such wide fields for application, and with such varied means of replacing laborious manual labour by rapid and powerful mechanism, the reasons for the development of the locomotive crane are apparent, and in its latest types it represents one of the most useful machines yet devised for handling materials of nearly every kind.

Manufacturing News

The Work of the Railway Business Association

THAT business men fail to make known, in a systematic or organized way, their desires as to legislation, except when individual companies have special measures to push or to kill, has been, and doubtless always will be, the complaint of those legislators who desire to know the needs of industry and business and to act accordingly. The interest which has the most capital invested and the largest number of men employed, namely, the industries manufacturing material and equipment for railroads, has until recently been silent at Washington and at the State capitals. Within the past month, however, this interest has found its voice and expressed in a very effective way its desires.

The Railway Business Association, which is comprised of manufacturers in that field, has made two notable demonstrations—the one at Albany, the other at Springfield, Ill. In each case a large party of the most important business men of the State journeyed to the capital. At Albany addresses were made before the Senate Committee on Judiciary by Mr. Otis H. Cutler, president of the American Brake Shoe & Foundry Company, as chairman of the committee in charge of the demonstration, and by Mr. George A. Post, president of the Standard Coupler Company, as president of the Railway Business Association. At Springfield Mr. Post was introduced by Mr. A. H. Mulliken, president of Pettibone, Mulliken & Co., and vice-president in Chicago of the Railway Business Association, and they addressed a session of both Houses in joint committee of the whole.

In neither case was there any buttonholing or lobbying. The deputation simply set forth the importance of the interests which it represented, the distress of the men looking to that interest for employment, and the importance of conservatism in legislation in order to reassure those charged with financing and carrying out railroad projects.

The New York Legislature has adjourned without adopting any of the measures which the Railway Business Association opposed, and though, as CASSIER'S goes to press, the Illinois Legislature has not yet adjourned, accounts from Springfield agree that the members in general were strongly impressed with the significance of what was said to them by the manufacturers.

This movement is so clear in its purposes, so clean in its methods, that great things may be hoped from it.

A New Baldwin Locomotive

IN connection with the article on "Remarkable Locomotives of 1908" in this number, it might be of interest to give a brief description of another remarkable type of locomotive, two of which have recently been completed for the Southern Pacific Company by the Baldwin Locomotive Works. They are Mallet articulated compound locomotives, having eight coupled wheels in each group, and, in accordance with the previous practice of the builders, are equipped with two-wheeled leading and trailing trucks. They are undoubtedly the heaviest engines thus far built for any railway. The constructive details embody various features of special interest. The calculated tractive force of this design is 94,640 pounds. The locomotives will be used on the Sacramento division between Roseville and Truckee, where the maximum grade is 116 feet per mile and the rating 1,212 tons of cars and lading.

The boiler is straight-stopped, and is equipped for oil burning. The fire tubes terminate in a combustion chamber, in front of which is a feed-water heater. A superheater, placed in the piping system between the high and low-pressure cylinders, is located in the smoke-box. The combustion chamber is provided with a manhole, so that the tube ends are readily accessible.

In order to facilitate repairs, the boiler is provided with a separate joint, which is placed at the rear end of the combustion chamber.

The waist-bearer under the combustion chamber is bolted into place, while the front waste-bearer and the high-pressure cylinder saddle are riveted to the shell. The longitudinal seams in the barrel are placed on the top center line, and have "diamond" welt strips inside. Flexible stay bolts are liberally used in the sides, back and throat of the fire-box, while the crown sheet is stayed with ⊥ irons hung on expansion links, in accordance with Associated Lines practice.

The dome, which is of cast steel, is placed immediately above the high-pressure cylinders, and the arrangement of the throttle and live steam pipes is similar to that used on heavy articulated locomotives previously built at these works. The exhaust from the high-pressure cylinders passes into two pipes which lead to the superheater. These pipes are of steel, and each is fitted, at the back end, with a slip joint, made tight with a packed gland. The steam enters the superheater at the front end of the device, and passes successively through six groups of tubes. It then enters a T-connection, from which it is conveyed to the low-pressure cylinders through a single pipe having a ball joint at each end and a slip joint in the middle.

Reversing is effected by the Raggonet power gear, which is operated by compressed air and is self-locking. The gear is directly connected to the high-pressure reverse shaft. The reach rod connection to the low-pressure reverse shaft is placed on the center line of the engine, and is fitted with a universal joint located immediately above the articulated frame connection. The joint is guided between the inner walls of the high-pressure cylinder saddle. In this way the reversing connections are simplified, and when the engine is on a curve the angular position of the reach rod has practically no effect on the forward valve motion. This arrangement has been made the subject of a patent.

One of the locomotives is equipped with vanadium steel frames and the other with frames of carbon steel. The connection between the frames is single, and is effected by a cast-steel radius-bar, which also constitutes a most substantial tie for the rear end of the front frames.

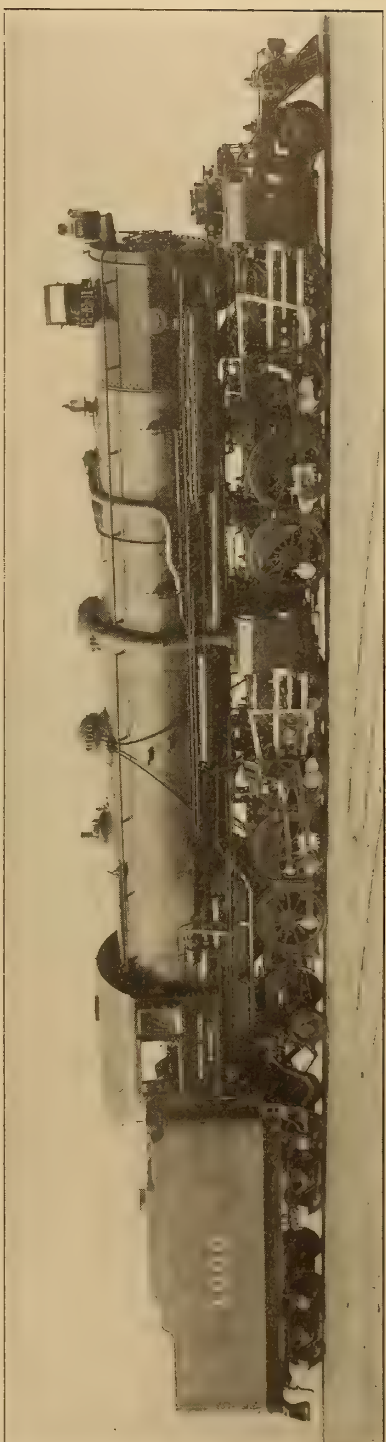
This locomotive naturally embodies in its design many smaller details of interest. The cylinder and steam chest heads are of cast steel, the low-

pressure heads being dished and strongly ribbed. The low-pressure pistons are also dished; they have cast-steel bodies, and the snap rings are carried by a cast-iron ring, which is bolted to the body and widened on the bottom. The links for the low-pressure valve gear are placed outside the second pair of driving wheels, and are supported by cast-steel bearers, which span the distance between the guide yoke and the front waist bearer. The low-pressure valve stems are connected to long cross-heads, which slide in brackets bolted to the top guide bars. The locomotive is readily separable, as the joint in the boiler is but a short distance ahead of the articulated frame connection, and all pipes which pass the joint are provided with unions. The separable feature was tested by the builders and proved entirely feasible. Sand is delivered to the rear group of driving wheels from a box placed on top of the boiler, and to the front group from two boxes placed right and left ahead of the leading drivers.

The tender is designed in accordance with Associated Lines standards, and is fitted with a 9,000-gallon water-bottom tank. The capacity for oil is 2,850 gallons. The trucks under both the locomotive and tender are equipped with "Standard" solid-forged and rolled-steel wheels.

The detail parts of this locomotive have, where possible, been designed in accordance with existing standards of the Associated Lines. The engine is practically equivalent, in weight and capacity, to two large Consolidation type locomotives, and, in spite of its great size, presents a pleasing and symmetrical appearance.

The contract for the foundations, including concrete piling, for the new six-story warehouse to be erected on Pier 2, Baltimore, Md., for the Standard Oil Company, has been awarded to the Raymond Concrete Pile Company, of New York and Chicago. Messrs. Haskell & Barnes, Baltimore, are the architects, and William Ferguson & Brothers the general contractors.



NEW MALLET ARTICULATED COMPOUND LOCOMOTIVE FOR THE SOUTHERN PACIFIC CO., BUILT BY BALDWIN LOCOMOTIVE WORKS.

The Arnott Steam Pile-driver

THE principle of effecting work by a succession of rapid blows instead of a fewer number of heavier strokes is meeting with wider applications continually. One of the advantages of this method lies in the fact that one blow follows before the actual effect of its predecessor has ceased, so that the operation becomes almost a continuous one. Another feature appears in the reduction in weight of the rapid-moving mechanism over that required for the slower apparatus.

Both of these are combined in the Arnott steam pile-driver, illustrated herewith, and made by the Union Iron Works, of Newark Street Station, Hoboken, N. J.

This apparatus is self-contained, the frame or body being one single casting, forming the cylinder, valve-chest and guides, and also enclosing the ram and the valve mechanism, thus protecting the working parts from injury. The safety buffers and pile plate are also within the frame, so that nothing but the inlet valve is exposed, and the whole machine is capable of resisting the rough usage to which contractors' machinery is subjected. The piston which actuates the ram receives the pressure of the steam or compressed air on top as well as beneath, so that the free fall of the ram is accelerated by the pressure. The travel of the ram while in operation is controlled at the bottom of the stroke by striking the pile, and at the top by the movement of the valve, safety buffers limiting any injury by over-travel. The smaller sizes of this machine do not require guides or ways, but may be conveniently handled by use of a small chain block suspended from a temporary beam above.

These pile-drivers are adapted for isolated or for sheet piling, and are made in six sizes, ranging from a total weight of 6,500 pounds down to a weight of 750 pounds.

Further information may be obtained from the manufacturers, the Union Iron Works, Newark Street Station, Hoboken, N. J.

Thomas A. Weston

IN noting the recent death of Mr. Thomas A. Weston, which occurred in New York at the advanced age of 78 years, we may call attention to some of the inventions of a man who was remarkable in many ways.

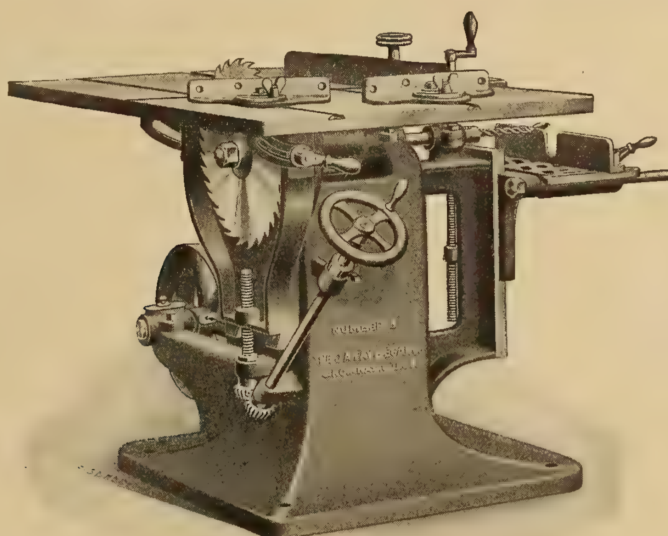
Born in England, Mr. Weston came to the United States when a young man, and first entered the hardware house of Pratt & Co., of Buffalo. His natural taste for mechanics caused him to give more attention to invention than to the commercial side of industry, and his first device, known all over the world as the "Weston" differential pulley block, has become so generally established as an elementary machine that it is sometimes included among the so-called "mechanical powers." Other inventions of Mr. Weston's which have found wide application are his multiple-disk friction clutch and his Triplex chain hoist, all of the above inventions having been developed and placed on the market by the Yale & Towne Manufacturing Company with much success. Mr. Weston also invented a number of improvements in small tools, and his skill and ingenuity in such directions were very great.

Personally, Mr. Weston was known to his many friends as a man of culture and wide information, and the keenness with which he attacked any mechanical problem presented to him showed the true inventor of the old school—intelligent, resourceful and apt.

A Variety Saw

IT is often a great convenience to have a machine which is capable of use for a variety of operations, and some very ingenious tools of this kind have been designed, especially in the department of wood-working machinery.

The illustration herewith shows a new "Variety" circular sawing machine recently placed on the market by the J. A. Fay & Egan Company, 226-246 West Front Street, Cincinnati, Ohio. The name "Variety" is well applied to this useful tool, since it is capable of performing a great variety of work otherwise requiring the services of a number of independent tools. All the various operations which can be effected by the use of a saw, in connection with proper guides, gauges, adjustable tables, etc., can be performed on this machine in the most accurate manner, including ripping, cross-cutting, bevel sawing, cropping, grooving, mitreing, etc. As shown in the illustration, the machine is also arranged for boring, so that it is very properly called a "variety" tool. An important element in such a machine lies in the facility with which the necessary adjustments can be effected, together with such solidity of construction and excellence of finish as will insure accuracy, and these features are combined with ease and quickness in converting it from one kind of work to another.



THE FAY & EGAN "VARIETY" SAW

Full information concerning this useful tool may be obtained from the builders, the J. A. Fay & Egan Company, Cincinnati, Ohio.

Air Compressor Lubrication

THERE is always danger where oils are used for lubricating air compressor cylinders, especially where the poorer grades of oil are employed. Many disastrous accidents have been traced to the receiver or pipe-line explosion caused by the vaporization of lubricating oils.

By using Dixon's flake graphite and oil fed by means of a graphoil lubricator, troubles with carbon deposits and dangers of explosion are reduced to a negligible quantity.

The booklet, "Air Compressor Lubrication," published by the Joseph Dixon Crucible Company, of Jersey City, N. J., contains much valuable information on the subject of air compressor cylinder lubrication.

News Items

The contract for the construction work involved in the Hydro Electric Development of the Grand Falls Power Company on the St. John River at Grand Falls, New Brunswick, has been placed in the hands of the Frank B. Gilbreth Organization of New York. Mr. John B. McRae, of Ottawa, Can., is the chief engineer, and Mr. Ralph Mershon, of New York, is the electrical engineer.

This plant will generate 100,000 horse-power in electric current, which will be furnished to the various cities throughout New Brunswick and Maine.

The work involves, among other features, the construction of a number of shafts in rock excavation 130 feet deep; a power chamber, 30 feet x 260 feet and 130 feet deep; and a tail race tunnel, 28 feet in diameter and 2,400 feet long; a power house, 350 feet long and 260 feet wide. The intake shafts will be 9 in number, 12 feet in diameter and 130 feet deep.

The Falls and water power on the St. John River at this point is the largest in Eastern Canada and its development will result in the establishment of a large number of manufacturing enterprises. The total head developed will be 135 feet. Numerous auxiliary works, sub-stations and long-distance transmission lines will be erected.

The St. John River at Grand Falls (which is the largest river in New Brunswick) describes a horse-shoe curve at this point, and has a fall of 135 feet through a gorge of the most magnificent scenic beauty. This spectacle is second only to that of Niagara, and its utilization, like that of Niagara, will result in a great increase in industrial activity in the province.

Grand Falls is situated on the Canadian Pacific Railroad about 200 miles north of St. John, N. B., and about two miles east of the State of Maine. The expenditure involved will amount to over $5,000,000.

The former American Boiler Economy Company, of Philadelphia, manufacturers of the Copes boiler feed regulator and the Copes pump governor, has been consolidated with the Northern Equipment Company, Old Colony building, Chicago, Ill., which will assume all obligations of the former company, including guarantees to replace free of cost any part of any Copes regulator that may develop a defect within five years from the date of purchase. The branch offices of the American Boiler Economy Company, viz., Tribune building, New York City; Oliver building, Boston; 226 East Pleasant Street, Baltimore, and the Frick building annex, Pittsburg, will be continued under the style of the Northern Equipment Company, while the sale of Copes regulators will be handled in Philadelphia by the Adjustable Grate Bar Company, North American building. The Northern Equipment Company announces that it will continue to install the Copes regulators on sixty days' free trial. The following recent sales to prominent concerns are mentioned: Nichols Copper Company, the Delaware & Hudson Railroad Company, the Clark Thread Company, the Consolidated Gas Company, of New York, and the Boston Elevated Railway Company.

The Robins New Conveyor Company has leased the entire building at No. 72 Front Street, New York City, and on April 1 removed its offices from No. 38 Wall Street to this new location. The machinery and other effects of the Duane Street factory are now being removed into the new quarters as rapidly as possible. The constant and material increase in the company's business is responsible for the change of location and the combining of offices and factory. Greatly increased facilities are provided by the new location, particularly for the manufacture of Robins laminated leather belting and Robins genuine balata belting.

THE LATEST CATALOGUES

Drills

American Specialty Company, Chicago, Ill. Catalogue describing the line of drills and sockets manufactured by this company. Lists of sizes and prices are also included.

Recording Instruments

The Brisol Company, Waterbury, Conn. Bulletin No. 103, just published by this company, describes a few of these instruments especially adapted for blast furnaces, including Bristol's recording pressure gauge, Bristol's recording thermometers, Bristol's electric time recorders, and the Wm. H. Bristol indicating and recording electric pyrometers.

Coal-Handling Machinery

Catalogue No. 091 of the C. W. Hunt Company, West New Brighton, N. Y., describes "Hunt" coal and ore-handling machinery and gives a large number of typical illustrations of power stations, gas companies, blast furnaces, coal yards, coaling stations, shipping docks, manufactories, boiler rooms, etc., in which such machinery has been successfully installed.

Fan Motors

Fort Wayne Electric Works, Fort Wayne, Ind. Bulletin No. 1,114 is presented with a greater realization of the popular demand for a useful, reliable, efficient fan motor. In these motors very little departure has been made from the standard line except that the smaller details of the present types have been perfected and new sizes been added in order to have a complete line of motors.

Drop Hammers and Forgings

The Billings & Spencer Company, Hartford, Conn. The general catalogue of this company, besides listing their large variety of machinists' tools, describes also their special machines, such as trimming presses, hot saws, heating furnaces and improved drop hammers. Standard automobile forgings, axle ends, steering connections, etc., are also among the products of this company.

Cable Joints

Dossert & Company, 242-244 West Forty-first Street, New York. Catalogue describing the Dossert solderless electrical connectors or cable joints for stranded or solid wire. These connectors are a very convenient means of making cable joints, obviating the use of solder and blow torches.

Water-Power

The Dodge Manufacturing Company, Mishawaka, Ind., have published an interesting book entitled "The Harnessing of Water-Powers." In it a number of plants where this company has installed all the machinery and appliances necessary to properly control and transmit water-power are mentioned and handsomely illustrated.

Storage Batteries

Gould Storage Battery Company, 341-347 Fifth Avenue, New York. Catalogue giving description and wiring diagrams for the installation of the Gould storage battery in isolated lighting plants.

Machinery and Tools

Brown & Sharpe Mfg. Company, Providence, R. I., manufacturers of milling machines, grinding machines, automatic gear-cutting machines, screw machines, cutters, accurate test tools, machinists' tools, etc., publish a very handy pocket-size catalogue, which they are pleased to send to any address upon application.

Ventilation

B. F. Sturtevant & Co., Boston, Mass. Booklet describing the Sturtevant "Ready to Run" electric ventilating set. These small sets are made specially for ventilating smoking-rooms, kitchens, sick-rooms, cellars, etc., and are furnished with canvas hose and cord and plug for connection to electric fixtures.

The Long Arm of Electricity

ONE of the most interesting results of the application of scientific methods and appliances to the service of man appears in the manner in which it has extended the reach of his natural members. Originally man was extremely limited in his physical powers; but, by reason of his superior mental equipment, he has succeeded in supplementing his deficiencies in this respect, and thus overcome his natural disadvantages. His lack of speed he has made up by the subjection of fleeter animals; and later, by the invention of mechanically-propelled vehicles on land, on the water, and, most recently, in the air. His weakness of muscle he has supplemented by harnessing the mechanical forces of Nature, developing water power, steam power and electricity. His comparatively insignificant size he has overcome by discovering methods for the control of similar forces, which enable him to communicate over distances of thousands of miles, to lift and convey burdens of many tons weight, and to control, by the touch of a button or the movement of a lever, mechanism which formerly required the immediate presence of an operative.

This means that the former limited reach of man has been extended in many ways. The old-time fable of the seven-league boots has been made a reality by the possession of the express train and the automobile; the vision through solid obstacles has been made possible by the discovery of the Roentgen rays; the ability to control action at a distance has been effected by the development of electrical appliances which permit him to govern apparatus of all kinds from any desired position.

It is this especial department of electrical control which is of much importance in many departments of mechanical engineering work at the present day, giving to the operator an arm of any length which may be necessary, and enabling him to control a variety of movements and operations.

The use of the electric motor has been especially effective in thus enabling distant control to be obtained, since it requires only suitable starting, stopping and reversing apparatus to enable almost any kind of machinery to be manipulated. When the apparatus is actually propelled by an electric motor, as in the case of an electric railway and electrically-driven machine tool, or similar application, the motor itself is directly controlled by the current.

Even when it is some other type of motor, as a steam engine or a hydraulic motor, the same principle applies, since an electric motor of proper size can always be used to control any larger machine, and thus permit the long electric arm to reach out to almost any distance.

It is not only starting and stopping, but detailed movements, which must often be controlled, as in the case of an electric crane, in which a heavy burden must be lifted, transported and deposited at a precisely determined point; or in the case of an elevator, where the car must be stopped exactly at the floor indicated with a minimum loss of time. These are only two illustrations out of many showing the necessity for accurate and reliable electric controllers.

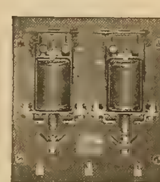
The electric controller may thus be considered as the brain of the nervous system of modern machinery, the wiring representing the nerves themselves, and the motors the muscular power. Just as promptness and efficiency in human action require a clear head, steady nerves and strong muscles, so, in the case of electrically-controlled mechanism, it is necessary that the motors should be of ample power, the connections properly made, and, above all, the controlling mechanism of the highest character, both in design and construction, as it forms the brain of the system.

CUTLER-HAMMER

Electric Controlling Devices

If you are interested in devices for starting, stopping or controlling the speed of an electric motor, tell us the result you wish to accomplish and we will send particulars of suitable apparatus.

Pump Starters



We can furnish promptly complete equipments for motor-driven pumps, comprising self-starter, copper float and float switch for open tank work, or self-starter and gauge type pressure regulator for use in connection with closed tanks or air compressors.

Printing Press Controllers

The Cutler-Hammer line of printing press controllers includes controllers for both platen and cylinder presses. We make also controllers for ruling machines, wire stitchers, folders, perforators, and other machines used in printing offices.

Machine Tool Controllers

No fewer than 30 of our Bulletins are devoted to controllers suitable for use with motor-driven machine tools. We can furnish controllers suitable for any class of machine tool, and can ship on short notice.

Elevator Controllers

Ask for Bulletins 51, 52, 53, 54, 56 and 57 covering the most complete line of direct and alternating current elevator controllers on the market. We make self-starters for electric elevators. Belt switches and reversing switches also. Bulletins on request.

Crane Controllers

Cutler-Hammer crane controllers were designed with a full knowledge of the severe service to which this class of apparatus is apt to be subjected. They are of exceptionally rugged construction and all parts subject to wear are made renewable and easy of access. Our illustrated, descriptive booklet on Crane Controllers is free on request.

The Cutler-Hammer Mfg. Co. Milwaukee Wisconsin

New York Office: Hudson Terminal (50 Church St.)
Chicago Office: Monadnock Block
Boston Office: 176 Federal Street

Pittsburgh Office: Farmers' Bank Bldg.
Pacific Coast Agents: Otis & Squires,
111 New Montgomery St., San Francisco, Cal.

Methods of Charging Blast Furnaces

A BLAST furnace may be regarded in one of two different manners, either as an apparatus for the reduction of a metal from its ore, or, more broadly, as a gas producer in which the sensible heat of the fuel is used for smelting purposes and the resulting gaseous fuel is discharged for subsequent use for power production. Thus, the gases which were formerly wasted have since been controlled, both for pre-heating the blast and for the generation of power for the various purposes of the works.

The older method of utilizing the furnace gases was by burning them under steam boilers for the supply of steam for the blowing engines and other machinery of the furnace; the more modern plan is to use these gases directly in the cylinders of internal-combustion engines in order to secure the higher efficiency thus attainable, and to use the power, not only for blowing the furnaces, but also for the supply of electrical energy in all its manifold applications.

In every case the furnace must be charged with fuel, ore and flux, this involving the handling of a large volume of material under conditions of peculiar difficulty. The older furnaces were charged by hand, a most laborious operation, and one which called for relief by the design of suitable mechanical appliances. At first the mechanical aid was furnished by lifts, carrying the barrows of fuel and ore to the top of the furnace, where they were discharged into the top of the shaft by hand. This method necessarily involved imperfect distribution, and had many disadvantages, the only relief appearing in the elevating of the material by power to the top of the furnace.

Subsequent methods have continually improved these first attempts to replace manual labour by power-actuated machinery, and in many of the large furnaces continuous delivery of material to the top of the shaft is made by extensive equipment. For small and medium-sized furnaces simpler systems have been devised, involving a lower initial cost, and yet performing the work in an entirely satisfactory manner.

Thus by the use of an industrial railway system in combination with a properly-designed lift it is possible to handle the charge for a blast furnace with a minimum labour cost, dispensing entirely with any manual work at the furnace top. The material is loaded on special cars and delivered to the platform of the lift, there being an industrial-railway track at the top of the furnace leading to the bell, into which the contents of the cars are automatically dumped, the empty cars being returned on the lift. The cage of the elevator is so arranged that the empty car descends while the loaded one is ascending, so that the delivery is nearly continuous. This method gives uniform distribution of the charge, and permits all the manual labour to be effected at the bottom, so that danger from the escape of furnace gases is obviated and the loss of gas kept at a minimum.

By taking the cars bodily to the track at the furnace top there is no intermediate transfer of the charge, the stock being carried from storage to the bell at the top of the shaft with but the one loading.

When a furnace is thus equipped its operation throughout is almost continuous, the raw material being fed in mechanically, the gases discharged continuously, not only for heating the blast, but also for the generation of power, while the metal and slag are drawn off below as they are separated. Thus one of the most laborious forms of manual labour has been replaced by mechanical appliances, reducing at the same time the actual cost of the work and relieving man from burdensome effort.

"HUNT" BLAST FURNACE EQUIPMENT

(Miller System)

For Small and Medium Furnaces

Carries the Stock from Storage to the Furnace Tops without transfer

No. 0787. Train of cars with sideboards taking material to the furnace top.

METHOD—When the cars reach the level of the furnace top, they are run off the cage on to an "Industrial" railway track over the bell into which the contents of the car are dumped, the construction ensuring perfect distribution.

No. 0790. Cars are taken up on the cage, the loaded car going up while the empty car is descending.

ADVANTAGES

Low cost of installation.
Perfect distribution.
Reduced labor.
Cost of operation.

As no manual work is done on the furnace top, accidents from gases reduced to a minimum.

EQUIPMENT DESIGNED FOR NEW AND FOR OLD FURNACES

Send for Bulletin E-1

C. W. HUNT CO.

West New Brighton, New York **New York Office, 45 Broadway**

Problems in Clutch Design

An important element in the design of power-transmitting machinery lies in the provision for throwing certain portions of the mechanism in and out of operative connection with the remainder. One of the simplest methods for accomplishing this result appears in the familiar fast-and-loose pulley, the belt being arranged to be shifted from one pulley to the other. Even this simple device has its difficulties, and the squeaking loose pulley is an occasional reminder that it is not so satisfactory to revolve the hole on the shaft as it is to turn the shaft in a hanger box. In many forms of transmission, notably those of a positive nature, such as involve direct shaft and gear connections, it is essential that some type of clutch be used; and the clutch problem has attracted the attention of many able engineers, with varying success.

The older clutches were of the so-called "jaw" type, involving the use of prongs or projections which make a positive and unyielding engagement with each other, this insuring freedom from slipping, but also including abrupt engagement, with resultant shock. Such clutches, when under heavy load, are also difficult of disengagement, owing to the pressure of the driving faces upon each other. These clutches were followed by various forms of friction clutches, the fundamental design being the cone clutch, in which one conical piece entered into a corresponding tapered sleeve. This form is still in use, and it operates fairly well if carefully made and maintained in good condition; but unless the taper is most carefully made it is apt either to slip or to jam, failing to hold in the one case or refusing to disconnect in the other.

Many other types of friction clutches have been designed, including the multiple-disc clutch of Weston and his followers, the ring clutches of other designers, and the numerous modifications of both forms. These have often given good service under the special conditions for which they were designed, but the results have shown that it is most desirable that clutches for any purpose should be made in accordance with a wide experience in power transmission.

A clutch which has given good results in one line of work may prove altogether unsuitable for a different service, and it is most desirable that the operative conditions be known to the manufacturer, and that he be given opportunity to bring to the special case under consideration the results of experience.

Considered in this light, the problem of clutch design becomes materially simplified. Whether the case be that of an automobile, a rope-drive system, a cement mill, a rolling mill, or a smelter, there is a type and design of friction clutch which will serve the purpose and which has already been evolved out of the operative conditions included in the work to be performed and the difficulties with which it is surrounded. In one case extreme sensitiveness is desired, in another a powerful gripping action. One clutch must be operated at a high speed with ease, another must be capable of immediate control under heavy load. What is right for one situation is necessarily unsuitable for another, and the only way in which success can be assured is to follow in the line of previous success.

Probably the best example of the perfection to which the friction clutch has attained for a special purpose appears in the modern automobile, this extensive use being a striking illustration of the application of frictional control of mechanism.

The entire tendency of modern design is toward the control of large masses of power-operated machinery by a limited number of operatives, and in the realization of such a control a powerful and absolutely reliable clutch is an essential.

The Shop-railway in the Air

THE value of space in a machine shop or warehouse is often measured in terms of floor space, and under older conditions this was doubtless most reasonable, since the overhead space was so encumbered with belts, beams and general obstructions that it was not taken seriously into consideration. To-day, however, it is not only the floor space which is utilized, but the whole available volume of the building, and thus the efficiency of a modern manufacturing structure is rendered much higher than was formerly possible.

Thus the modern shop is designed in such a way as to provide for the installation of traveling cranes, of various kinds of conveyors, of industrial railways and similar appliances, covering not only the portions of the floor available for the transport of material and product, but also utilizing the space above the machinery and operatives for the handling of objects which might otherwise be transported only with material loss of time and effort.

One of the most convenient elements in such utilization of overhead space in the shop is the so-called tramrail, or overhead system of beams, arranged to sustain loads suspended from trolleys and chain hoists, and to permit material to be transported to any point beneath. Such a system is the natural complement of the chain hoist, extending its scope and converting it into an organized means for effecting one of the most important elements in modern manufacture — the movement of product through the shop.

The origin of the overhead tramrail—or shop railway in the air, as it has been termed—is, like many other useful shop elements, very simple, being merely an extension of the short bar placed above the lathe or other machine tool to enable the hoist to be brought into position at any point above. Under the natural development of growth such a bar became extended into a straight rail, enabling one chain hoist to serve several machines, and thus the expansion to an overhead system, serving the entire floor, became entirely logical.

Simple as the idea of the overhead tramrail may seem, its development involved the perfection of a number of ingenious devices, and the skill of the engineer found abundant opportunity for exercise in the production of detalis which have rendered this equipment one of the most effective features in modern shop outfit. The mere construction of a satisfactory trolley includes features of special value, since it must have strength, reasonable lightness, smoothness of running, ease on curves, and be commercially producible. The extension of the rail itself to various parts of the building involves the design of crossings, switches, turntables, and the proper supports and connections. When all is done, however, we have available a complete system of transport, rendering the simple chain block capable of almost indefinite extension, covering three dimensions, instead of one, and providing the mechanic with an arm which is both long and powerful.

Here, again, we see the success which has attended the work of the engineer in eliminating the brutalizing influence of excessive physical effort, and in replacing it with appliances which substitute for the severe strain on the muscles the judicious action of the head. The man who works with his brains must always be more efficient, both for his employer and for himself, than the man who works only with his hands; and it is the worthy contention of the engineer that he has made this possible by many devices, probably by none more effectively than the combination of the chain hoist and the overhead rail upon which it is carried.

Manufacturing News

Hydraulic Jacks

ANYONE who has much heavy lifting to do appreciates that there are pleasanter tasks than carrying around a jack from one place to another, especially when it weighs more than a hundred pounds. It means rather a heavy load if carried by hand, and, if the jack is loaded and reloaded onto a truck with each using, this involves considerable work.

The new Watson-Stillman shop jack, which we show in the first illustration, renders unnecessary much of this labour. This jack, made in eleven sizes, of from 20 to 50 tons capacity and lifts of 12 and 18 inches, fills all the ordinary requirements of lifting heavy machinery and for general shop work. The wheels on the base and the handle on the cylinder facilitate moving the jack quickly from one place to another without the exertion of a great deal of energy. The wheels touch the floor only when the jack is tilted, so they are never in the way during the lifting operation. If it is desired to use the jack at an angle, it can be tilted in the opposite direction to the wheels, and when it is laid flat upon the side the ram will push out its entire lifting length. The head is enlarged sufficiently so that the jack will not stop working for lack of filling even if there has been slight leakage. An independent steel claw (not shown in the illustration) can be used when desired for lifting from near the ground. This is more convenient than a permanently attached claw, as

NEW HYDRAULIC JACK. THE WATSON-STILLMAN COMPANY, 50 CHURCH STREET, NEW YORK

the independent part is easily applied when a low lift is required, and its removal at other times allows the jack to be made of considerably lighter weight. The weight, however, is comparatively small, because the whole jack is made from steel,

and the parts under greatest strain, such as the ram and cylinder, are machined from a solid bar of higher carbon steel than is usually found in hydraulic or other jacks. This jack, though plain in construction, has proven very reliable in service, and, on account of its special design, greatly facilitates the handling of heavy equipment.

It is sometimes inconvenient to work the lever of a jack of the internal pump type because of the lack of room or insufficient footing. There are other places where only a short space is available to place the jack—another condition which cannot be met successfully with the ordinary inside pump jack. This is especially true in bridge, ship and dry dock work, etc. Even in more common work it is sometimes to the operator's advantage, in the way of getting a better footing, more power or safety, to be at a considerable distance away from the jack. To meet these conditions the Watson-Stillman Company put upon the market the independent pump hydraulic jack shown in the second illustration, and which they furnish in fifty-three sizes of from 2 to 1,200 tons capacity. The various sizes of the jack proper have maximum ram movements of from 4 to 8 inches. The pump is connected to the jack by means of flexible copper tubing, which may be of any length suitable to the work in question. The jack may be operated up to a pressure of 450 pounds per square inch on the ram by means of the hand lever shown on the pump, and further worked to full capacity by means of the extension lever. The gauge may read in pounds per square inch, or in tons load upon the jack, or both. This is not furnished when the jack is to be used for ordinary lifting, but is necessary in testing. When equipped with the gauge, the jack may be used between two fixed platens for making compression tests, testing the tightness of forced fits, etc.

INDEPENDENT PUMP HYDRAULIC JACK. THE WATSON-STILLMAN COMPANY

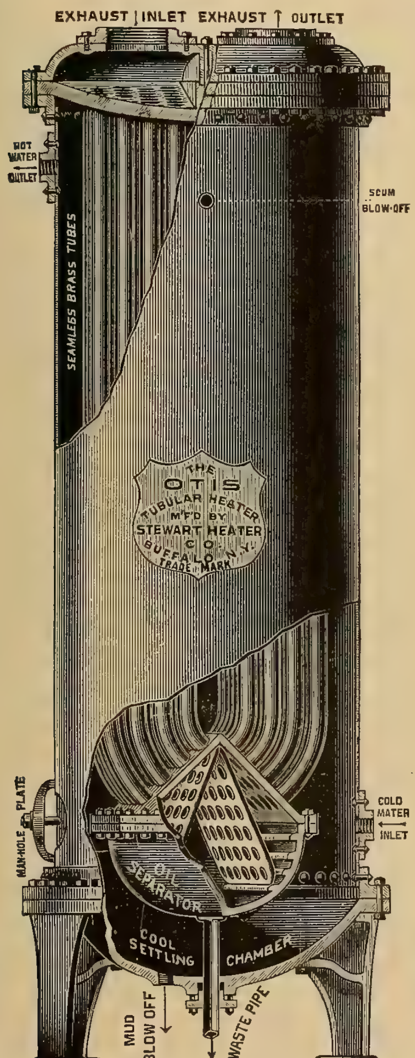
Both of the above jacks are made by the Watson-Stillman Company, of New York, and embody the usual Watson-Stillman characteristic of being able to stand a considerable overload without danger of injury to the operator or jack.

The Otis Heater

THE illustration on the next page shows the Otis tubular feed-water heater, oil separator and purifier. The main object of this apparatus is, as the name partially indicates, to thoroughly heat the feed-water by the exhaust steam before it enters the boiler; also, to separate the mud and sediment from the feed-water and remove it easily and quickly from the heater; also, to collect and carry off the scum from the surface of the water and to collect and carry off the condensation and

oil from the exhaust of the engine.

The body or shell of the heater is made of boiler iron or steel, the top end of which is riveted to a heavy cast-iron ring, with a projecting ring cast upon its outer surface,



THE OTIS TUBULAR FEED-WATER HEATER, OIL SEPARATOR AND PURIFIER. THE STEWART HEATER COMPANY, BUFFALO, N. Y.

forming a flange, to which the tube sheet and top dividing plate is attached by one row of bolts. The lower end of shell is riveted to a heavy cast-iron conical bottom, which is supported by four legs, making a very substantial base for the heater.

In operating the heater the exhaust steam enters the heater at the top, as shown in the illustration, passes down one section of tubes into the enlarged space of the water and oil catcher, where the water of condensation and oil is separated, and the exhaust steam then passes up through the other section of the tube, thus passing twice through the entire length of the heater, heating the feed-water to the boiling point. The exhaust steam can then be used for other purposes or exhausted into the atmosphere.

The water enters the heater near the bottom, and, passing upwards in contact with the heated tubes, gradually becomes thoroughly heated, and is discharged as near the top as practicable without carrying the scum that is on the surface of the water into the boiler.

Rope Drive for Alternators

THE extremely slight variations above and below normal speed in each revolution of the most carefully governed steam engine have always introduced features of difficulty in the operation of alternating current generators in parallel.

The exact synchronism of two or more such electric machines when engine-driven has been very hard to attain and maintain. Many of the technical journals have printed numerous articles on this subject of parallel operation, showing that the problem is one of extreme perplexity.

Alternators rope-driven never cause any trouble if their power sources are reasonably made, always with great success when properly designed. One of the most important of modern large-scale applications of rope driving for alternators is that at the Rock Hills (S. C.) hydro-electric station of the Southern Power Company, Charlotte, N. C.

This plant has eight generating units, four of 750 kilowatts each and four of 900 kilowatts, making a total

rated capacity of 6,600 kilowatts, for which upwards of 10,000 horse-power of driving capacity is provided in the water-wheels and rope drives.

Originally the four 750-kilowatt units were installed, and later the larger 900-kilowatt generators were added, with Dodge drives for power connections, thus completing the equipment.

The driving sheaves are 14 feet 3 inches in diameter, built double and grooved for twin 17-wrap drives of 1½-inch rope. They are mounted directly on the extended shafts of the horizontal turbine water-wheels, so the driving connection to the generators is absolutely direct.

Tension carriages roll on inclined tracks, and the slack is delivered to them over winders placed in the single unit. Each complete drive is good for 1,800 horse-power at ordinary rating, which would correspond to about 50 per cent. overload for the generator. Turbine speed, 110 revolutions per minute; generator speed, 360 revolutions per minute; current generated at 11,200 volts, three-phase.

This plan of station arrangement elevates the generators above the level of the dam crest, away from the moisture of the wheel pits, and where good light may be had through windows on both sides of the power house.

The drives, as installed by the Dodge Manufacturing Company, Mishawaka, Ind., are noiseless, non-slipping, steady, elastic, direct, highly efficient, and in every way satisfactory for the kind of service mentioned in this article.

Westinghouse Turbines in Detroit

THE Detroit United Railways recently placed a contract with the Westinghouse Machine Company for another turbine unit. This company already operates Westinghouse turbines in three of its power stations—the central plant in Detroit, the Baltimore station of the Detroit & Port Huron Railway and the Munroe station of the Detroit & Munroe Railway. The new turbine, which is 1,000 kilowatts capacity, and which is to operate at 150 pounds steam, 28 inches vacuum and saturated steam, will be installed at the Rochester station on the Detroit & Flint Division. This station already contains engine type units, but extensions of traffic have necessitated the installation of this new turbine unit. The Flint Division is about 62 miles in length, with central station at Rochester and sub-stations at intervening points, and operates heavy, high-speed interurban cars, reaching the center of Detroit over the city lines. The system is operated by high-tension, alternating-current transmission, originally supplied through inverted rotaries, but with the installation of the new unit direct from the turbo generator. The direct-current equipment will then be used for feeding directly into local sections of the distributing system, while the alternating current machine will carry the outlying portions of the line load.

The Industrial Instrument Company supply data on their instruments in the form of engineering bulletins, each bulletin being devoted to a certain line or class of meters, or to those instruments of different classes that group themselves conveniently for a certain industry. The various bulletins published by this company are 8 x 11 in size, and punched for binding together in substantial covers. These covers and any bulletins will be sent to engineers interested in instruments upon application to the Industrial Instrument Company, Foxboro, Mass.

An engineer's manual, containing all practical and technical data necessary for estimating correct size for installation and operation of the Reeves variable speed transmission, is being published by the Reeves Pulley Company, Columbus, Ind.

S. S. George Washington

THE largest German trans-Atlantic liner afloat arrived in New York on June 21. She is named in honor of the first President of the United States, and was built in the yards of the Stettiner Vulcan, at Bredow, for the North German Lloyd. She is constructed as a first-class twin-screw passenger and freight steamship, having the most up-to-date improvements.

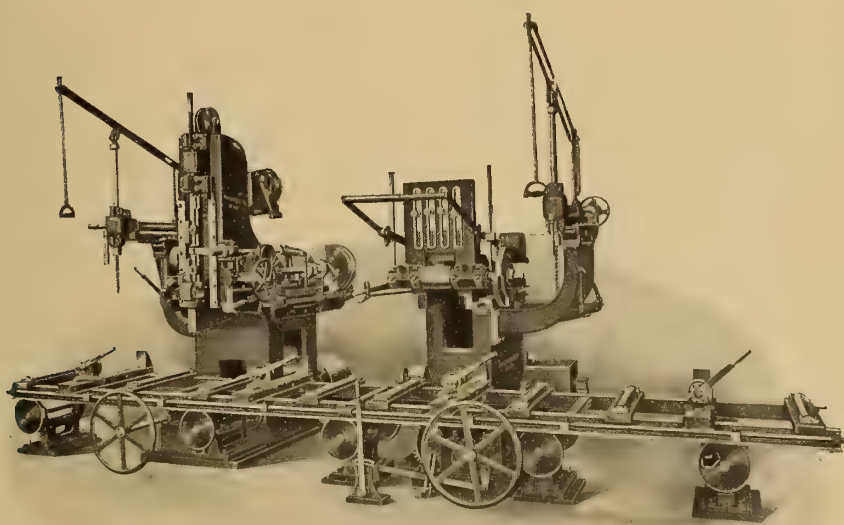
Some idea of her proportions may be had from the following dimensions: Length, 722 feet 5 inches; beam, 78 feet; depth from upper saloon deck, 54 feet; depth from awning deck, 80 feet; speed, 18.5 knots; displacement at 33 feet draught, 37,000 tons; gross registered tons, 27,000; horse-power, 20,000; cargo capacity, 13,000 tons.

A Combined Mortiser and Gainer

THERE has been a long-felt need among bridge constructors and car shops for a machine that would do heavy mortising and gaining on a piece of material without moving it from one machine to another.

The J. A. Fay & Egan Company, at 226-246 West Front Street, Cincinnati, Ohio, are the first to introduce a machine of this kind to the trade. We take pleasure in illustrating same herewith.

In constructing this machine the manufacturers have placed their No. 214 vertical, hollow chisel mortiser and No. 150 automatic car gainer side by side with a single traveling carriage.



COMBINED NO. 214 VERTICAL HOLLOW CHISEL MORTISER AND NO. 150 AUTOMATIC CAR GAINER. THE J. A. FAY & EGAN COMPANY, CINCINNATI, OHIO

The machine has capacity for timbers up to 20 inches thick and 24 inches wide.

The two heavy auxiliary boring attachments angle to 30 degrees in either direction. They have transverse movement full width of the table and a stroke of 18 inches.

As our space is limited, which prevents us giving a detailed description of this machine, you are invited to write the manufacturers for their circular showing a large half-tone photograph of this machine and giving full description.

News Items

The Engineers' Society of Pennsylvania has an established fund to provide prizes for meritorious designs of engineering structures.

At this time prizes are offered for the best design of ornamental poles for the support of lights and trolley wires. Plans, specifications and estimates of cost must be submitted. The competition is to close July 15, when the designs submitted will be opened by the Board of Award. For particular information, address Paul A. Cuenot, Chairman Prize Committee, Engineers' Society of Pennsylvania, Harrisburg, Pa.

Mr. J. R. Bibbins, who since 1902 has been associated with the Westinghouse interests at Pittsburg, Pa., recently serving the Westinghouse Machine Company as commercial engineer, on June 18 became associated in the work of the Public Service Commission, of New York, as assistant to Mr. B. J. Arnold, Consulting Engineer and Director of Appraisals. Mr. Bibbins is a graduate of the University of Michigan, and has served in various technical capacities with the Detroit Public Lighting Commission, the Detroit Edison Company and the Detroit United Railways Company in operating and construction work. During his late connection with the Westinghouse Machine Company Mr. Bibbins' work has included an intimate association with the development of prime movers at East Pittsburg, including gas engines, producers, turbines and condensers. His new offices are in the Tribune building, City Hall Square, New York.

An improved appliance recently brought out by the Green Fuel Economizer Company, of Matteawan, N. Y., for so regulating the draft of steam boilers that the pressure within the fire-box is at all times neutral is described in a pamphlet entitled "Automatic Draft Control for Steam Boiler Furnaces." To keep this pressure neutral, just enough pressure is supplied under the grates to force the air through the fuel, while enough draft is applied in the smoke flue to draw the gases of combustion through the boiler. This is said not only to give the ideal proportion of air for perfect combustion at all loads, but also to prevent the escape of flame and hot gases of combustion through the open fire-door and through crevices in the brick setting, as where forced draft is used, while also preventing the drawing in of cold air and the dilution and consequent cooling of the gases of combustion, as where induced draft only is used.

This system of draft has an important bearing in connection with the researches which have recently been made by the engineers of the United States Geological Survey with the object of increasing greatly the rate of steam production per square foot of heating surface in boilers.

The ninth session of the Summer School for Artisans of the University of Wisconsin began June 28, continuing for six weeks. Courses are offered in steam and gas engines, electricity, machine design, mechanical drawing and allied subjects.

There are no entrance requirements, the purpose of this school being to offer practical instruction by lectures and laboratory practice to young men in the trades.

Certain advanced engineering courses are offered, and the general university summer session held during the same period allows opportunity for a wide choice.

A new feature of the coming session will be courses in public utilities testing and accounting for those desiring to become familiar with the requirements of the Railroad Commission of Wisconsin, which has the administration of the Wisconsin Public Utilities law. Information may be obtained from F. E. Turneaure, Dean, College of Engineering, University of Wisconsin, Madison, Wis.

MANUFACTURING NEWS

The Raymond Concrete Pile Company, of New York and Chicago, has been awarded the contract for the concrete pile foundations for the ten-story, 54 ft. x 100 ft., fireproof warehouse to be erected at 139-141 Franklin Street, New York, for the Strohmeyer & Arpe Company, importers; Maynicke & Franke, architects; Chas. H. Peckworth, contractor.

The A. B. Dick Company have just put on the market a new machine called the planotype, which prints through a ribbon in exact imitation of typewriting.

This machine is a type duplicator designed to cover the field of office work between that of the rotary mimeograph and the high-priced printing press.

In the vast majority of cases, the rotary mimeograph meets every requirement for duplicating, and is the quickest, simplest, most economical and practical device. The remaining demands are filled by the planotype.

Full information regarding this new machine can be had by writing to the A. B. Dick Company, 161-163 West Jackson Boulevard, Chicago, Ill.

Mr. E. H. Stevens, who is well known among steam-power plant and central station men as the general superintendent of plants of the Public Service Corporation of New Jersey, has resigned that position to become vice-president and general manager of the Bird-Archer Company, manufacturers of boiler compounds, 90 West street, New York.

During his fifteen years' experience in power-plant operation costs and management, Mr. Stevens has had complete charge of plants aggregating several hundred thousand horse-power, and is therefore exceptionally well prepared to deal with questions about feed-water treatment. Mr. Stevens' genial disposition, courtesy and engineering ability have won for him the respect and esteem of all with whom he had come in contact, and his many friends wish him all success in his new work.

Dr. N. Clifford Ricker, head of the Department of Architecture of the University of Illinois, gave a very interesting paper on the "Investigation of Base Plates" before the American Society for the Advancement of Science at a meeting held some time past at Baltimore, Md.

The paper presented the results from extended study, including the deduction of accurate formulas for plates of the usual forms and materials, with the addition of graphic tables for the rapid and convenient solution of the problems of the architectural engineer. There were a number of lantern slides of charts and the results of tests.

Meetings were recently held at the United Engineering Society Building, in New York, at which the permanent organization of the American Society of Engineering Contractors was effected. This new national society begins its career with a membership of 1,500.

Officers for the first year were elected as follows: George W. Jackson, of Chicago, president; Halbert P. Gillette, of New York, first vice-president; D. E. Baxter, of New York, second vice-president; and Daniel J. Hauer, of New York, temporary secretary. These officers with the following gentlemen will make up the board of directors: De Witt V. Moore, of Indianapolis; Edward Wegmann, of New York, and W. D. Lockwood, of New York, to serve one year; W. S. Hanson, of Chicago, George Warren, of Boston, and J. R. Wemlinger, of New York, to serve two years; and Major Cassius E. Gillette, of Philadelphia; F. C. Hitchcock, of New York, and Howard J. Cole, of Morristown, N. J., to serve three years. Application for membership can be made to the Temporary Secretary, 721 Park Row Building, New York.

THE LATEST CATALOGUES

Pumps

DEAN BROS. STEAM PUMP WORKS, Indianapolis, Ind. Catalogue No. 77 should be of special interest to owners of Dean pumps, inasmuch as it contains lists of parts of pumps, directions for operating pumps and tables of information.

Locomotives

BALDWIN LOCOMOTIVE COMPANY, Philadelphia, Pa. In record No. 66 published by this company three interesting papers are discussed. They are on "The Smoke-Box Superheater," "The Feed-water Heater" and "The Advantages of the Use of Moderately Superheated Steam in Locomotive Practice."

Milling Machines

NILES-BEMENT-POND COMPANY, New York. Handsomely illustrated catalogue, describing their various lines of heavy milling machines, rotary planers, vertical milling machines, etc.

Rock Drills

INGERSOLL-RAND COMPANY, 11 Broadway, New York. The "Sergeant" rock drills, their principle and mode of operation, are well described in Form No. 4002. Numerous examples of the work these drills are capable of accomplishing are also illustrated.

Dustless Roads

BARRETT MANUFACTURING COMPANY, New York. An interesting booklet is published by this company: How to construct and preserve macadam roads and how to prevent dust by means of applying tarvia to the roads. Tarvia is a coal-tar product, and is made specially for the treatment of roads.

Steam Shovels

THE BROWNING MANUFACTURING COMPANY, Cleveland, Ohio. Bulletin No. 33 gives a general description of Browning standard revolving steam shovels. They can be operated either by electricity or steam, as may be desired, and are designed for general railroad work, stone quarries, brickyards, sand and gravel pits, excavating cellars, etc.

Recording Gauges

THE BRISTOL COMPANY, Waterbury, Conn. Bulletin No. 104 lists a very complete line of recording gauges for pressure and vacuum. In listing these instruments the bulletin shows an actual section of nearly every chart listed, the section itself appearing along with the catalogue number, code word, and other data.

Fly-Wheels

THE DODGE MANUFACTURING COMPANY, Mishawaka, Ind., are the publishers of an interesting little treatise on "The Safe Construction and Speeds of Fly-wheels." Stresses and strength, split and sectional wheels, the problem of high speed, and fly-wheel design are the subjects discussed in the treatise.

Electric Time Systems

THE INDUSTRIAL INSTRUMENT COMPANY, Foxboro, Mass. Bulletin No. 22 treats on standard electric time systems as particularly developed for use in industrial and commercial plants. Such systems, if installed in large manufacturing establishments, are of great value in promoting economy in the use of time and in systematizing and standardizing manufacturing operations.

Belts

JOSEPH DIXON CRUCIBLE COMPANY, Jersey City, N. J. Booklet entitled "The Proper Care of Belts." It deals with the running condition of belts, their treatment with various preparations, and some general points upon belting and its use. It can be obtained by writing directly to the Joseph Dixon Company.

BOOK NEWS

Governors

Shaft Governors, Centrifugal and Inertia. By Hubert E. Collins. Size, 4½ x 7 inches. 127 pages, with 35 illustrations. New York: Hill Publishing Company. Price, $1.00.

This is one out of a series of books called "The Power Handbooks," and treats on simple methods for the adjustment of all classes of shaft governors. It is made up from material originally published in *Power,* together with some special articles which have been prepared to make it a complete handbook of the subject. The fact that nowhere in a single book can all this material be found in a form which will be useful to the practical engineer will, it is hoped, make the book of special interest and value.

Brennan's Handbook of Legal Information

A Compendium of Useful Information for Business Men. By B. A. Brennan, contract manager of the Westinghouse Machine Company, Pittsburg, Pa. Size, 4½ x 7 inches. 571 pages. New York: John Wiley & Son. Price, $5.00.

The work is offered to business men not as a positive guide or counsel on the matters treated, but more to enable them to familiarize themselves to some extent with the legal requirements for business and some of the fundamental principles of law. It is based upon personal contact and experience with the various questions arising in daily business intercourse, and recognized authorities have been followed. A synopsis of the statutes bearing on the collection laws of the different States, as well as a number of useful legal forms, are also contained in the book.

The Gas Engine

By Cecil P. Poole, editor of "Power" and "The Engineer." Size, 6 x 9 inches. 97 pages. New York: Hill Publishing Company. Price, $1.

The basis of this work is The Gas Engine Supplement which Mr. Poole prepared for *Power* a year and a half ago. The book is not intended as a complete treatise on the subject. The object of the author is to present the principles governing the salient features of gas-engine construction and operation in as simple a manner as possible, and to that end academic discussions of the characteristics of gases and hypothetical heat-energy cycles of the character commonly found in text-books have been avoided. Since the pressures, temperatures and energy transformations which occur in a gas-engine cylinder cannot be adequately explained without the use of algebraic equations, which appear complex to a beginner, such equations have been employed in that connection; but their use has been restricted to a single chapter. This chapter may be omitted without sacrifice by readers who wish merely general, rudimentary information, but not by real students of the subject.

Mining

A Study of Ore Deposits for the Practical Miner. By J. P. Wallace. Size, 6 x 9 inches. 349 pages, with 124 illustrations. New York: Hill Publishing Company. Price, $3.00.

This is a book intended for the average miner, the prospector and the mining public. It is eminently practical, of simple language, concise in statement and deals only with essentials. A knowledge of minerals, ores and rocks is important to a correct understanding of ore deposits, for all are intimately associated. A brief description of the most important of these is given. The structural features of ore deposits and the walls enclosing them, together with the form, origin, and manner of occurrence of deposits, have been given special attention. No attempt at classification of ore deposits is made, further than to group under separate heads those deposits which have certain structural conditions in common. Descriptions of prominent mines of various types and forms are presented, chiefly to exemplify and enforce the principles set forth governing the disposition of ores.

The Flow of Solids

THE idea of flow is generally associated with the movement of liquids and gases, and, indeed, the term fluid is usually restricted to these two states of matter. Nevertheless, it is beginning to be understood that nearly every substance is capable of a movement corresponding to the idea of flow, and that such a thing as absolute rigidity does not exist. Indeed, if there were a condition of perfect rigidity it would be accomplished with what might be termed the property of absolute brittleness, a most undesirable state of affairs.

The flow of solids occurs in such mechanical operations as the drawing of wire, the manufacture of drawn tubing, the production of various shapes in the forming press and in the spinning lathe, and all these are well known to the engineer. To the general observer it is apparent that we have in the mountain glacier an example of continuous flow of an apparently solid mass, and that, too, without rupture or disintegration.

The one great example of a fluid material, however, is water; and it has long been an important department of the work of the engineer to effect the movement of water by elevating it from a lower level to a higher, and thus allow it to be distributed by gravity through channels and pipes.

One of the most efficient methods of thus handling water consists in the use of scoops or buckets lowered into the stream from poles, or beams, and raised to be emptied into elevated ditches for distribution. This very ancient method is practiced in Egypt to-day, as it is shown chiselled in the monuments of more than three thousand years ago, and its efficiency is as great now as it was then.

To-day, however, we have to effect a flow of solid materials which are not in continuous masses, as is the ice of the glacier, but rather in what may be termed the granular form, materials such as ore, gravel, sand, coal, and the like. To cause these to flow involves the use of some device similar to that found satisfactory for water, but modified to serve for the granular nature of the material. As yet we have not been able to pump coal or gravel, although devices have been constructed which carry large volumes of such solids suspended in currents of water. The ancient bucket, however, has shown itself amenable to the requirement, and to-day we may see the overhanging booms reaching out from their towers over the water in which cargoes of granular solids are floating, while shovels lift tons at a time and raise them to the higher level from which they flow, by means of automatic railways, to the storage bins, ready to flow again through distribution channels, as directed.

Thus we have a system of flow not unlike that of the modern irrigation methods, except that it is a solid, and not a liquid, which is distributed.

The modern bucket resembles the ancient, however, only as some highly organized machine resembles the simple elements from which it has been evolved. From a few pounds its capacity has grown to tons; the muscular effort of man has been replaced by the power of steam or electricity, and the reach of a few feet has been extended to yards of lift and unlimited distances for distribution.

As the tower, boom and bucket represent the modern development of their prototypes in the old-time well-sweep or the Egyptian "shadoof," so the automatic railway is analogous to the aqueduct through which the irrigating stream of water flowed to the fields. The stream of coal, however, flows to the furnace; the ore to the smelter; the sand or gravel to the concrete mixer. Nevertheless, it is a flow, although the materials are solid, and it forms one of the most efficient methods of moving solids to-day, as it has been for liquids from the earliest times.

Power Distribution

IN the utilization of mechanical power much depends upon the methods employed for its distribution, so far as the question of efficiency is concerned. The old idea of heavy belts from the engine to the jack shaft still appears in many cases, while in other instances the use of rope transmission is seen to be successfully applied.

The question of transmission and distribution must be clearly differentiated in considering this problem. It is generally conceded that it is more advantageous to generate the power of a large establishment in one central power house than to have a number of engines situated in various parts of the works. This latter condition being accepted, the next stage in the problem is that of the transmission of the power to the various departments, each taking a considerable portion of the whole, and then in each department providing such methods of distribution to the several machines as may seem most convenient under the local conditions.

Belting will doubtless always be used for many purposes of power transmission, but belting has its limitations. When the distance between the centres of the shafts is limited within certain amounts it is difficult to secure satisfactory results with belts, since the tension must be kept excessively high, and the stresses upon belts and bearings become so great as to present operating difficulties.

Again, it is often desirable to transmit power to shafts at angles with the main driving shaft, and with belting it then becomes necessary to use the objectionable quarter-turn belt, or to use guide pulleys and similar devices to control and direct the belts in the proper path.

For such conditions the development of rope transmission has provided a solution which is at once effective and satisfactory. By using the American system, employing continuous rope passing a number of times around a pair of grooved pulleys, with idler puller to take up the slack, it is practicable to transmit large powers between shafts situated very close together and at the same time to avoid excessive tension upon the rope and consequent pressure upon the bearings. Under such conditions slipping is no more possible than it is when a cable is passed several times about a post, as in the mooring of a vessel to a wharf, while at the same time there is ample elasticity to provide for the fluctuations in the tension.

When shafts are not parallel there is a special advantage in the use of the continuous rope drive, since it is possible to provide for any angle which the conditions may demand without the slightest inconvenience in the transmission of the power, and without any of the inequalities and irregularities in wear which are inevitable with the use of belting under similar conditions. A belt is essentially a flat surface, with possibilities for use in wrapping around cylindrical drums or pulleys, while a rope is in itself cylindrical, and is capable of application upon any surface, whether plane, cylindrical or warped.

It is evident, however, that the varied applications of rope driving cannot be mastered upon inspection. There are many questions connected with rope drive which have been solved only by the lessons of experience and trial. The amateur who attempts to design a successful rope drive for an intricate transmission may succeed, but the experienced engineer who has made the method a study for years is certain to do so.

Like every other mechanical device, it has its broad applications, its special uses and its limitations, and these should all be considered in the light of expert knowledge and experience, if success is to be expected.

Overhead Tramrail

IN the installation of overhead tramrail for use in connection with chain blocks for the transport of material in the shop even such a simple element as the trolley from which the chain block is suspended, and by means of which the load is carried along the rail, demands skill in design and experience in manufacture. When the older forms of chain block first came into use in the shop such a thing as a trolley was not an article of manufacture at all, nor was there any systematized arrangement of tramrail adapted for the service. The rail was made of flat bar iron, hung from home-made brackets or suspension pieces, the curves, when there were any, being shaped in the smith shop and the whole laid out in a rather rough and amateurish fashion.

The trolleys themselves were as varied in design as there were shops in which they were used, and the controlling elements in the construction of this part of the equipment were usually to be found in the constructive limitations of the particular establishment where it was to be used. In some cases the body of the trolley was cut from plate metal, and in other instances a piece of flat bar iron was bent into a yoke and fitted with a loop or clevis, from which the chain block was suspended, and with fixed pins upon which the trolley wheels were mounted.

With the development of the manufacture of transport appliances into a specialized department of machine construction the trolley naturally received attention, and the results of experience and a study of the conditions of operation have become crystallized into certain standard types which have survived the ordeal of severe shop service. These various forms have become standard articles of manufacture, which means that, while they must necessarily be better adapted for the duty they are called upon to perform, they actually cost materially less than the crude contrivances which they have superseded.

It was soon found that the flat-bar tramrail could be advantageously replaced by the commercial steel I-beam, this furnishing a double bearing on the upper sides of its lower flange for the trolley wheels. The stresses were thus centralized, while the trackway was of a form which did not accumulate dirt and which was readily accessible.

With this modification in the rail there became possible the four-wheeled trolley, admitting the introduction of equalizing connections between the two sides, and also permitting the construction of double bearings for the wheels. An important point thus secured is the provision of axles fixed in the wheels and running in bearings, a device as superior to the loose wheel as a pulley with journal bearings is better than the ordinary loose pulley on a shaft. It is also practicable to fit such trolleys with roller-bearings for their wheels, the resistance being thus reduced to a minimum, and the wear also eliminated to a great degree.

In some cases a geared trolley is desired, thus enabling the load to be moved along the rail by the use of a hand chain.

With such a geared trolley and a modern hand hoist of high efficiency a combination is effected which can be used either with tram rail or upon a light crane to form a hoisting equipment of great convenience and efficiency, second only to similar devices fitted with electric power.

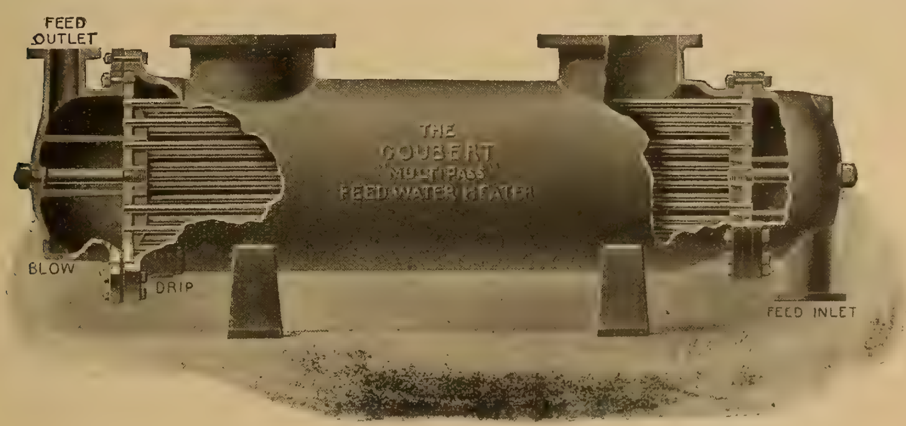
In some instances it has been found advantageous to use the combination of overhead tramrail, trolley, and chain block in outdoor work, such as the mixing of concrete, and the like, the rail being carried upon temporary trestles, and the material being brought in buckets, enabling the predetermined proportions of sand, gravel, and cement to be measured while the material is being transported.

Manufacturing News

Some Points About Feed-Water Heaters

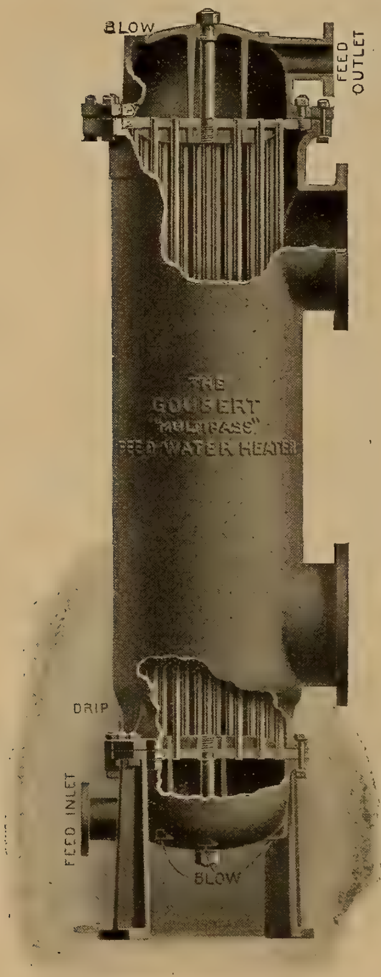
PROTECTION against oil getting into the boilers is a prime factor of ultimate power-plant economy and safety wherever heat from the exhaust steam is utilized for preheating the feed-water. If oil-laden exhaust comes into direct contact with the supply water, the oil particles will, if not removed, collect on and ruin the boiler heating surfaces. The seriousness of this may be inferred from the fact that in many large plants running condensing, as in some of those of the New York Edison Company, the water of condensation and its contained heat are thrown away, just to avoid letting the oil from this condensation get to the boilers.

It is a fair assumption that protection from oil is as important a requirement as is the heating efficiency. These requirements are well met in the new Goubert "Multipass" heater, recently introduced, and made in sizes of from 50 to 5,000 horsepower by the Goubert Manufacturing Company, of New York. This apparatus, guaranteed by the manufacturers to heat feed-water from ordinary temperature to within 10 degrees of the temperature of the



GOUBERT MULTIPASS FEED-WATER HEATER, HORIZONTAL PATTERN

exhaust steam, represents the highest type of closed heater. The Goubert heater consists essentially of two cast-iron water chambers connected together by a cluster of small, straight brass tubes, which, in turn, are enclosed within a cylindrical



VERTICAL PATTERN OF FEED-WATER HEATER

cast-iron shell extending from one water chamber to the other. The exhaust steam enters the shell by the upper opening shown at the right, and what does not condense passes out the lower opening. That which is condensed on the tubes flows to the bottom of the shell and passes out through a drip pipe. It is a peculiarity of this construction that oil or grease in the steam is removed as in an oil separator and passes off with the drip, leaving the remainder of the exhaust steam in the best possible condition for heating systems and other purposes where live steam is sometimes used.

In the steam tube type the mud and sediment tend to settle at the bottom among the tubes, where it is difficult to remove, while scale that may form on the tubes is also difficult to get at. One great advantage of having the water within the tubes, as in the Goubert heater, is that the scale may be removed without taking down the heater. It is obvious that by removing the top chamber the tube interiors can be examined and cleaned out with little difficulty. But the greatest advantage of the water-tube construction is that which gives the Goubert heater its name "Multipass." There are baffles so placed in upper and lower chambers that the feed-water entering at the bottom must travel back and forth through several sets of tubes and be subjected to the heat of the steam several times before it can reach the outlet at the top. In a 700 horse-power Goubert Multipass heater, for instance (handling 21,000 gallons of water per hour), there are 100 tubes, each 1 inch in diameter and over 7 feet long. The feed-water must travel five times the length of these tubes in the path of the steam, which gives every opportunity for absorbing the largest practicable amount of heat.

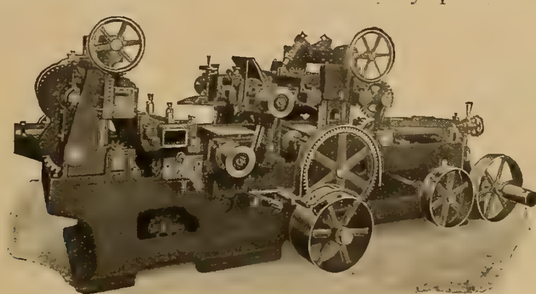
The differential expansion of parts of a feed-water heater is, with some constructions, a matter which gives much trouble. For this reason the Goubert heater is provided with an expansion joint between the upper chamber and the shell. The upper chamber is supported entirely by the tubes and left free to move up and down. The expansion joint is fitted with a flexible ring gasket composed of layers of soft copper and special

packing with wire interwoven. The inner edge is clamped between the shell and an annular ring. The only purpose of this gasket is to prevent steam from escaping into the room, and, as it is subjected to no other pressure than atmospheric, the gasket will last for years. Its renewal amounts to nothing more than the replacing of a cylinder head or steam-pipe gasket.

The vertical construction as described is preferable, but for installations where there is not sufficient head room the horizontal heater shown can be used. This has the same essential features as the vertical type, and is also useful in connection with condensing engines. If it is desired to suspend the horizontal heater from the ceiling, the feet may be replaced by straps, lugs or bolts.

Double Cylinder Planer and Matcher

THE machine shown herewith is manufactured by the J. A. Fay & Egan Company, at 226-246 West Front street, Cincinnati, Ohio, and is equally efficient as a floorer and also a moulder.



NO. 159 DOUBLE-CYLINDER PLANER AND MATCHER.
THE J. A. FAY & EGAN CO., CINCINNATI, OHIO

The cylinders are made of solid forged steel and are four-sided and slotted on each side, making them adaptable to the use of moulding, beading and patent siding knives.

It is made in five sizes, to work 10, 15, 20, 24 and 30 inches wide and up to 8 inches thick.

The manufacturers, in describing this machine in their large illustrated circular, call special attention to the construction of the feed works, consisting of four double-geared down-driven rolls. The two upper in-feeding rolls are carried on a pair of side housings and are both raised and lowered at the same time by hand wheel shown in the illustration. The out-feeding rolls are driven from the in-feeding end of the machine by chain and sprockets. You will notice on the cut the spring pressure to the upper in-feeding rolls, doing away with the old system of cumbersome weights and levers.

There are no studs on this machine; all gears are keyed to shafts running in self-oiling bearings.

For further information you are requested to write the manufacturers, who make a complete line of wood-working machinery.

Westinghouse Turbines for Lighting Pennsylvania Tunnels

THE Pennsylvania Tunnel & Terminal Company, operating the Pennsylvania Railroad tunnels under New York City and the rivers, is installing in its Long Island City power house two Westinghouse turbine alternator sets of 2,500 kilowatts capacity each, for lighting the tunnels and terminals. The dependability required in this service has demanded that every precaution be taken to insure absolute continuity of operation of the generating and distributing systems. The alternators will supply three-phase, 60-cycle current at 440 volts.

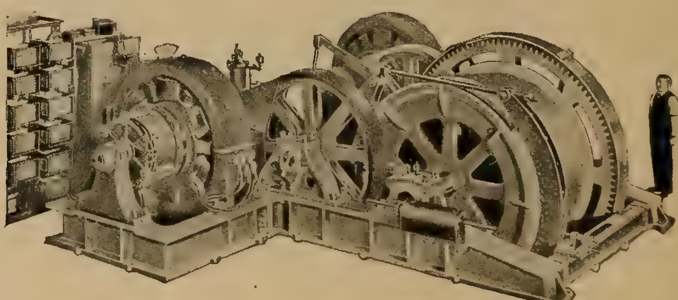
Electric Hoist for Handling Pier Cars Carrying 130 Tons Load at Sewall's Point

THE coal-shipping terminal at Sewall's Point, near Norfolk, Va., of the newly opened Virginia Railway just completed by Mr. H. H. Rogers at a cost of something like $40,000,000, is operated in a novel manner, and contains some very interesting machinery, including a 1,000-horse-power electric hoist, designed and built for the purpose by the Lidgerwood Manufacturing Company, of New York.

The pier has a capacity for handling thirty cars per hour, 15,000 tons in ten hours, or 4,500,000 tons per year of 300 working days. Eventually the plan calls for four such piers, giving a capacity of 18,000,000 tons a year.

The design of the pier and equipment was adopted so as to enable the company to bring coal from the West Virginia mines to the seaboard in gondola cars, which could be utilized for taking other freight westward. As the road expects eventually to have fully 5,000 cars in service, this was considered particularly desirable.

that bring it to tidewater into the hoppers, from which vessels are loading, comprises two operations. In the first of these, the cars are allowed to drift down by gravity, one by one, to where a barney car can pick them up and carry them up a short incline to a dumper. The dumper picks each car up bodily, tips it to an angle of 65 degrees, so that the coal is poured out into a special conveyor car of larger capacity to be taken to the hoppers on the pier. There are ten of these special conveyor cars. They are the largest cars of this kind ever constructed. They are of steel, with hopper bottoms, and each carries a load of 100,000 pounds of coal. As soon as each conveyor car is loaded, it is taken in hand by the big hoist, which, by means of a barney car, draws it up a 25 per cent. incline at a speed of 480 feet per minute. The incline is 480 feet long. It takes 45 seconds for the car to reach the knuckle. Once upon the higher level and past the "knuckle" of the incline, the conveyor car proceeds down the pier under its own power, as each is equipped with electric motors taking power from an overhead trolley and controlled from



LIDGERWOOD ELECTRIC HOIST FOR HANDLING PIER CARS; VIRGINIA RAILWAY

The terminal designed will not only be the largest for its purpose in the world, but it is the most up-to-date in every part of its equipment.

The coal pier is 1,860 feet long from the shore line to the main harbour channel. It is of steel, resting on concrete foundations. The operation of getting the coal from the cars

a cab at the end. The big hoist returns the barney car to the foot of the incline, ready for another trip, at a speed of 555 feet per minute. The round trip is made in 1 minute and 20 seconds. The conveyor car goes to hoppers along the pier and deposits its load wherever it is wanted. The hopper bottoms of the cars are

operated by compressed air, supplied by automatic electric compressors on the cars.

Having deposited its load the conveyor car returns by a kickback system, which allows it to drift back down a gentle incline to the bottom of the slope to be refilled.

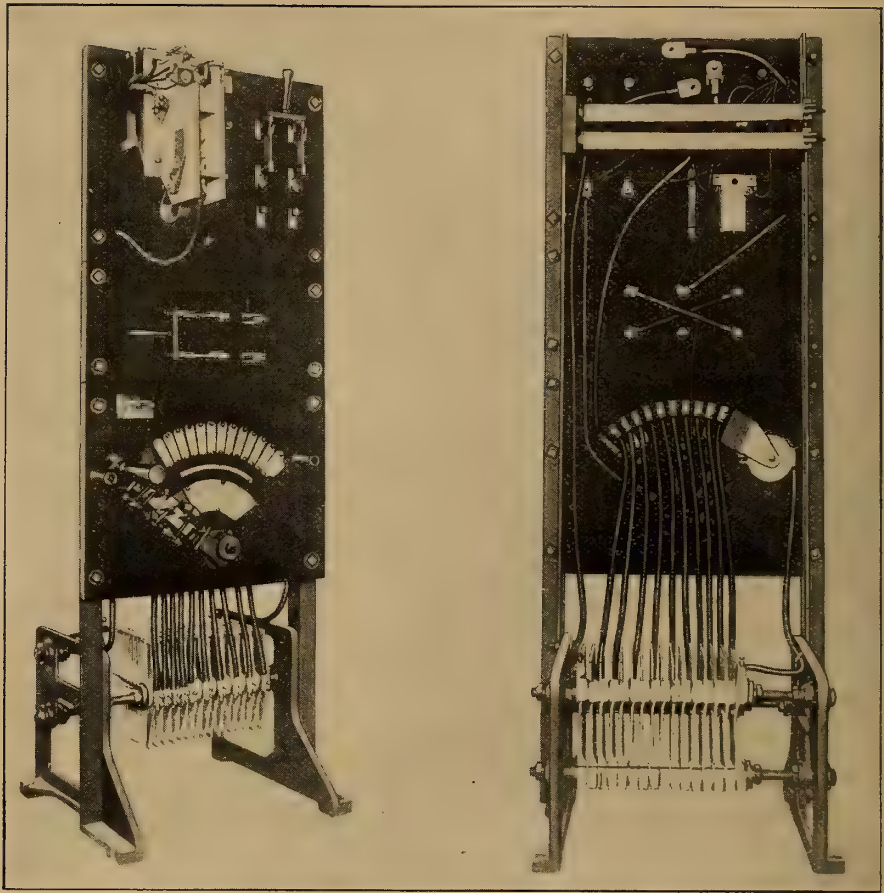
The Lidgerwood hoist which hauls the conveyor cars up the incline is an interesting part of the equipment. Each conveyor car with its load weighs nearly 200,000 pounds. The hoist complete, with its two motors, weighs 180,000 pounds. But one motor is used at a time, the other being provided to insure constant operation. The motors are of the General Electric Company's make of the M. P. Co. class. They are rated at 550 horse-power, and actually develop 980 horse-power each. The drum of the hoist is 84 inches in diameter, with a face of 42½ inches in width, grooved for a 1¾-inch main cable, and having also a section with a 7-inch face grooved for a ¾-inch tail rope for insuring the return of the barney car. The flanges are 6 inches in depth. The main gear wheel is 116 inches in diameter. The pinion which drives this is 19 inches in diameter. The intermediate gear wheel is 72 inches in diameter, with a 21-inch pinion. All the gears are of cast steel, with machine-cut teeth.

The drum has powerful post brakes. These are controlled by a solenoid, through the medium of compressed air. The compressed air is supplied at a pressure of 80 pounds to the inch by an electric compressor, which forms part of the hoist outfit. The general operation of the hoist is controlled by an operator near the barney-car pit, 350 feet distant from the hoist, but the hoist is provided with an emergency limit switch which makes certain that it cannot overwind in either direction. The brake is set by a weight of 1,400 pounds acting upon a suitable lever. When the current is turned on, the solenoid acts, and by means of the compressed air releases the brake. When the current is cut off, whether by intention or accident, the solenoid drops, releases the air, and the weight brings the brake into action, holding the load safely in any position.

Engine Balancing

THE problem of balancing high-speed steam engines is discussed in a clear and exhaustive manner in a pamphlet that is being distributed by the American Engine Company, Bound Brook, N. J. It is well known that balancing the ordinary simple engine is an impossibility without the use of "bob-weights;" that is, reciprocating weights moving at right angles to the piston; further, any attempt at balancing in one direction introduces equal unbalanced forces in a direction at right angles. The author then proceeds to show how an engine can be balanced perfectly if two cylinders be suitably arranged, and gives a brief description of the American angle compound engine in which this idea is incorporated. It is pointed out that the perfect balance obtained makes it feasible to install this engine upon upper floors and in other places where vibration would be objectionable, also that the even turning moment incidentally secured makes it possible to use lighter fly-wheels, and results in less pressure upon bearing surfaces, besides giving more satisfactory operation of alternating-current generators. Copies of the pamphlet will be sent gratis to engineers interested in the subject.

Mr. Ernest Schmatola, metallurgical and chemical engineer, has issued two interesting lectures in pamphlet form. The one on gas firing was a lecture given before the English Ceramic Society, and the other a paper on gas producers and gas firing, and the advantages of gas firing over the direct use of coal, which is reprinted from the *Mining Journal*, February 6, 1909.



MILL-TYPE MOTOR STARTER—THE ELECTRIC CONTROLLER & MFG. CO., CLEVELAND, OHIO

New Line of Motor Starters

RECOGNIZING that there is a demand for a motor starter of rugged construction, the Electric Controller & Manufacturing Company, of Cleveland, Ohio, have developed and placed on the market a new line of starters which are essentially of mill-type design.

In designing these mill-type motor starters the Electric Controller & Manufacturing Company have attempted to interpret severe operating conditions, and this has necessarily led to the use of some features not found in any existing motor starter. Mill-type motor starters are made in panels, have supporting feet, and are completely self-contained. The dimensions of the different forms vary only in height. In width nothing projects beyond the slates, so that adjacent starters may be placed side by side, forming a continuous control board. The starters are furnished in several forms, beginning with a very simple form and elaborated on to embrace such features as no voltage release, overload protection for running, and separate and different overload protection for accelerating. In explanation of the last-named feature, this design allows more current to flow through the motor during starting than during running. If a motor be connected to a load having large inertia—such as a hot saw or a press with a heavy flywheel—the mere accelerat-

ing of the load demands a very considerable expenditure of work. Yet the starting time will be materially reduced. There are, in fact, numerous instances where it is desirable to allow an accelerating current larger than the running current.

Experience has shown that no-voltage protection, which is secured by a spring return arm, is open to the following serious objections: First, the spring is likely to be either broken or weakened, so that upon voltage failure the arm does not return to the off position. Second, the contacts may become so roughened that the spring is not powerful enough to move the arm. Third, an ignorant operator may block the arm in the off position, so that it is impossible for the spring to properly perform its function.

If, through any cause, the arm is not returned to the off position upon voltage failure, the motor will necessarily be subjected to a damaging overload upon the return of voltage. In the mill-type motor starters the danger of a broken or weakened arm spring is absent, because no such spring is used. The no-voltage protection is secured entirely by a magnetic switch which opens upon failure of voltage. This same magnetic switch, in connection with an overload coil, is used for securing overload protection. Since the overload feature must stand the abuse and have the characteristics of a circuit breaker, the Electric Controller & Manufacturing Company believes that it should possess the advantages and arc-breaking ability of a circuit breaker.

The following valuable features summarize the operation of this type of motor starter:

First, the magnetic switch can be closed only by bringing the arm to the off position, preventing injurious overloads to the motor upon the return of voltage after voltage failure.

Second, the magnetic switch can be held close to the arm or any accelerating step only by holding in a push button. This prevents leaving any of the starting resistance permanently in circuit, and thereby burning out this resistance.

Third, the magnetic switch will maintain itself closed only when the arm is at the full-on position.

The resistance, fingers, contacts, etc., used in the mill-type motor starters are of the same design and kind of material that the Electric Controller & Manufacturing Company use in controllers for heavy service. This motor starter can therefore be rightly called of mill-type design and is well able to stand the same abuse and severe service which the most ruggedly constructed mill-type motor can be expected to encounter.

Personal

Mr. Edward G. Dewald, heretofore manager of the water wheel departmnet of the Platt Iron Works Company, Dayton, Ohio, has become identified with the hydraulic turbine department of Allis-Chalmers Company, as special representative for the Pacific Coast, with headquarters at 599 Mission street, San Francisco. Mr. Dewald has been with the Platt Company for the past twenty years, during five of which he served as manager of its San Francisco office; and he has been identified with many of the largest hydraulic power installations in the country, including the majority of those on the coast.

Mr. H. Almert, an engineer of long practice in Chicago, has been appointed manager of the department of examinations and reports of H. M. Byllesby & Company, with headquarters at Chicago.

W. R. Thompson, late of the Public Service Commission of New York State, and formerly with Westinghouse, Church, Kerr & Co., has been appointed assistant to the chief engineer of H. M. Byllesby & Company, with headquarters at Chicago.

Notes

AN interesting example of the application of a gas producer to marine work can be found in the launch Gloria. The producer and engine, which have been designed by Stephen A. Hasbrouck, M. E., give the boat a speed of nine miles per hour at a cost of 4½ cents.

The Gloria is 54 feet long, 11 feet beam, 5 feet deep and draws 4½ feet of water. She is a heavily-built converted steam yacht. The engine is a four-cylinder, four-cycle, 25 horsepower Hasbrouck motor.

The plant takes up very much less space than steam and weighs much less. It needs very little attention and requires charging only every three to five hours, there being nothing else required the rest of the time, so that a producer plant needs very little more work than a gasoline engine.

The remarkable feature about the producer plant is its wonderful economy. The gas is made from hard coal of pea No. 1, buckwheat size, and when it is considered that a producer gas plant can be run for one quarter the expense of a small steam plant, and one-half of that of a large one, and for one-eighth the cost of one using gasoline, the wonderful field that is opened to the marine power user is at once evident, for it means a reduced coal bill, fuel that can be obtained anywhere, eliminates all danger of exposion, as it is a fuel that will not leak out at joints and fill the boat with dangerous gas.

The complete plant in the Gloria, including engine and producer, weighs about 120 pounds per horsepower, and occupies a space of 9 by 2 feet.

During the past winter the Gloria has had installed a new and larger plant, incorporating several new and important features, so that the cost of propulsion has been reduced still more, enabling the Gloria to run 600 miles on one ton of coal. This means that a 54-foot boat is able to go to Bermuda and back on less than three tons of coal. Besides, the engine runs just as smoothly on producer gas, and there is just as wide a range of control of speed with throttle and spark as with gasoline.

The Hasbrouck Marine Producer Gas Power Co., 161 Lexington Avenue, New York, will be pleased to give a demonstration at any time, and give all information they can to anyone who is interested.

"How to Save Coal" is discussed from the point of view of recovering waste heat in the chimney flue gases in a neat little booklet which is being distributed by the Green Fuel Economizer Company, of Matteawan, N. Y. The booklet further describes the construction of the Green economizer, illustrating the new extended top header, the new bottom header especially designed to avoid choking from soot, the new sectional covering and other improved features. There are several illustrations of large plants, such as the D., L. & W. terminal power plant, which have recently been equipped with Green economizers and Green mechanical draft fans.

The contract for the construction of the concrete pile foundations and concrete pile bulk-heads for the J. S. Young Company plant, of the MacAndrews-Forbes Company, Boston and Elliott Streets, Baltimore, has been awarded to the Raymond Concrete Pile Company of New York and Chicago; C. Montgomery Anderson is the architect for the work.

"The Hydraulic Properties Company, of Providence, R. I., have awarded the exclusive agency for all construction of Ransom & Hoadley's reinforced concrete dams to the Frank B. Gilbreth Organization, No. 60 Broadway, New York City." This is an important news item, due to the fact of the great interest that is taken in water-power construction throughout the country at the present time.

THE LATEST CATALOGUES

Bridge Railings and Fences

Chester B. Albre Iron Works, Allegheny, Pa. Catalogue No. 9 covers new designs in bridge railings, new illustrations of fences, circular stairs, and benches are also included. Sizes, details of connections, etc., are all indicated, so as to be of real assistance in designing and drawing up fence specifications.

Gasoline-Driven Locomotives

Milwaukee Locomotive Manufacturing Company, Milwaukee. In publication No. 100 the various gasoline locomotives made by this company are described. They are specially adapted for service in manufacturing plants, mills, lumber yards, mines, plantations, etc.

Rope Driving

Dodge Manufacturing Company, Mishawaka, Ind. Twenty-five years of rope driving is the name of a catalogue which reviews the development of the American system of rope transmission from its introduction by Dodge Manufacturing Company. It contains valuable information for the mechanical engineer and the power user generally. The book is profusely illustrated with views of actual installations, and has numerous line drawings showing the design and arrangement of the drives. It is free to mill and factory managers, superintendents and engineers who are interested in the mechanical transmission of power.

Ball-Bearing Trolley Base

The General Electric Company has recently issued Bulletin No. 4,658, the type US-14 ball-bearing trolley base. The type of double ball bearing used on this base produces an extremely sensitive action, which, by eliminating the arcing, pounding, wrenching, etc., inherent in ordinary forms, insures a minimum wear on trolley wheel and overhead construction. A cushioned stop is provided to protect the pole from bending or breaking should the wheel leave the wire. This publication contains also a list of supply parts for this base.

Turbines

The Ball & Wood Company, Elizabethport, N. J. The Rateau-Smoot turbine and generator, which has many advantages in producing power effectively and economically, inasmuch as it is a low-pressure turbine, and makes use of exhaust steam, is well described and illustrated in the new catalogue issued by this company.

Blowers

American Blower Company, Detroit, Mich. This company have just issued a new catalogue descriptive of the "Sirocco" fan. Some of the advantages claimed for it are: increased efficiency, resulting in a saving in horse-power for same capacity; increase in capacity of fan for the same power; smaller space occupied for a given capacity for the same space occupied; slower speed, resulting in quiet operation.

Reinforced Concrete

Concrete Steel Retaining Wall Company, Cincinnati, Ohio. Pamphlet published by this company describing the Bone system of reinforced concrete retaining wall construction, together with some matter on the general principles of the design of such walls.

The General Fireproofing Co., Youngstown, Ohio, publish a catalogue in which they describe all material designed by them for each requirement in reinforced concrete work, such as square lug bar, cold-twisted lug bar, expanded metal, wire fabric reinforcement.

Wattmeters

Fort Wayne Electric Works, Fort Wayne, Ind. Bulletin No. 1115, issued by this company, illustrates their new single-phase integrating induction wattmeter type K_2.

Scientific Devices in Daily Use

IT has often been said that familiarity with marvelous things renders them commonplace, and this is especially true with the enormous extension in the public use of devices which but a few years ago were seen only in the scientific lecture room and laboratory.

The business man of to-day rides to his office in an electric car taking its propelling power from a slender wire connected to an electric generator in a distant power-station. If he notices the motorman at all he pays little attention to what may be in the case to which the controlling handle is attached, and yet within that small space is the concentrated ingenuity of electrician, engineer and instrument maker.

At his office there stands on his desk, in the form of a telephone transmitter and receiver, one of the scientific marvels of the age, and yet, so familiar has it become that he thinks no more of it than of some primitive speaking tube of earlier days. From his window he may see, stretched between poles on the roof of some near-by hotel, a few parallel wires, at which he may have gazed with brief interest when some one told him that they served to pick up messages transmitted through space without wires from vessels yet hundreds of miles from shore.

When such things as these were shown to him at some scientific lecture or professional gathering he listened with respectful admiration; now that they have become familiar objects, together with many other examples of applied science, he scarcely considers them; unless, indeed, his attention is directed to them as subjects for commercial undertakings or of manufacturing enterprise.

Probably there is no one thing which has done more to further the entrance of applied electricity into daily life than the development of devices by which it may be controlled, and through it a control exercised over other appliances. That a man of moderate mechanical ability may stand on the front platform of a car, and by a few movements of his hand control its movements and speed, is due to the perfection of the controller. To the fact that similar devices have been perfected for use in the machine shop, the business building and the factory, is due the extending use of electricity for the operation of machine tools, elevators, looms and spinning frames. Whether in hotel or residence, on railway train or steamship, the presence of electrically-operated devices of all kinds may be a continual reminder that back of all these things there must exist somewhere some effective devices by which they are controlled, just as surely as there is in the brain of man a power controlling his muscular actions.

One of the interesting things about such controlling devices appears in the fact that apparatus which, in the hands of the professor in the laboratory, was handled with extreme care and delicacy, has, in the hands of the engineer in the workshop, become as sturdy and rugged as any other mechanical appliance which is sold on the open market and intrusted to ordinary workmen. This result has been accomplished without in any degree diminishing the reliability or sensitiveness of the apparatus. On the contrary, the practical electrical engineer has developed, from the few crude pieces of lecture-room apparatus, a line of devices involving the production of new inventions adapted to the numerous demands of actual daily service, thus creating powers of control of a variety and extent hitherto undreamed of.

Out of just such demands there has arisen a new and extensive manufacturing business devoted to the production of regulating and controlling devices of a character far surpassing the old lecture-room apparatus.

It is a far cry from the key of the first Morse telegraph to the modern automatic controller, starter or switch, but all are developments of the application of electricity to the service of man through the efforts of the scientific engineer and manufacturer.

The Question of Repairs

EVERYTHING may be said to have a life, whether it is animate or inanimate, whether it is a man or a machine, and the effectiveness of that life depends not only upon the original character of the thing itself, but largely upon its capacity for endurance. The brilliant man often fails to hold on tenaciously enough to carry out the projects which he may have conceived, and the ingenious machine may break down at the critical moment, or it may fail to last long enough to warrant its original cost.

It has been said that a machine may be made too well, that it may outlive its usefulness, and that instead of meeting the condition that "the best is good enough," it is better to remember that "the good enough is best." Both positions are worthy of consideration, and each should be applied in accordance with the particular considerations in hand. It is a manifest mistake in making a pattern from which only one casting is ever to be required to give it the same care, finish, and high-grade material as that given to one from which thousands of standard castings are to be made. It is also a mistake to design a machine which must have a life of ten or twenty years in such a manner that its various parts have not the elements of strength and endurance to meet the demands of the service during that period. It is a still greater mistake to underestimate or to overestimate the legitimate life of a machine by making it unable to last as long as it should, or by making it outlive its period of usefulness when it should be superseded by an improved and later design.

It is a well-known practice in some departments of engineering work to drive the equipment for all it is worth, to work it to death, so to speak, and to get the maximum output from it, with the distinct understanding that it must earn its depreciation in the limited life period thus predetermined. This makes it clearly understood that the machine is not expected to stand any definite repair charge, but that, when it does give out, it is to be superseded by a new machine, presumably of a later type and of a higher efficiency. When it is clearly understood that this is the method of operation, the designer and builder can proceed accordingly. In many cases, however, it is essential that a machine shall have a long life, that the cost for repairs shall be a minimum, and that the efficiency of the plant shall include its continuous and active operation during the life which has been predetermined for it.

It is upon such considerations that the various methods for estimating depreciation are based. An apparatus which is as good after twenty years' service as it was when it was installed, and which has been maintained in such condition with a minimum cost for repairs, is evidently to be charged with but a trifling amount yearly for depreciation. In such cases the principal element in depreciation is not the actual wear and tear upon the machine itself, but the progress of the state of the art to which it belongs, and the extent to which this progress has rendered it old-fashioned and behind the times.

Of course, it is not always possible to foresee the changes which may take place in any department of mechanical industry, and hence it is wise to assume that the depreciation charge against any machine should be sufficient to sink the original cost in a period in which its usefulness may be safely assured. At the same time it is one of the evidences of skill in design to produce an apparatus of such effectiveness that it is able to maintain itself in the face of continued development, and thus outlast, not only a conservative depreciation period, but also the working life of competitive devices.

Aids to Human Effort

IT is interesting to the student of human development to observe the extent to which man has overcome his natural disadvantages, and by the sheer power of intellect has caused his relative weakness to be so supplemented by mechanical contrivance as to give him far greater physical powers than the greatest animals which have ever existed.

When the steam engine was placed upon a commercial basis by Watt and his successors it seemed entirely natural that its power should be expressed in terms of the effort of the horse, and in spite of all later suggestions for new units, the horse-power remains as the measure of the greatest aid to human effort which has yet been produced.

The engines of to-day have their power expressed in terms of thousands of horses, and this power is distributed and applied very largely by means of electricity, this method permitting both a convenient distribution and unequaled facility in control and manipulation.

The horse-power is expressed in terms of foot-pounds, or, in other words, by means of the idea of lifting a weight, and it is to the lifting of weights that electrically-transmitted power has been most effectively applied. By the successive developments in hand appliances for purposes of hoisting, the comparatively feeble strength of man has been supplemented by the block-and-tackle, the differential hoist, and by the more efficient duplex and triplex chain blocks. Even with these perfected appliances, however, a limit is reached where it becomes necessary to call in additional power, and thus we come to the more highly organized machine for converting the foot-pounds produced by the engine, transmitted by the current, again converted into mechanical power, to reappear once more as many pounds, lifted through spaces at will—we come to the electric hoist.

The electric hoist fills a position midway between those occupied by the hand-operated chain block and the heavy power crane, a field, curiously enough, left for development until after the other extremes had been well cultivated. The highly efficient triplex block was in extensive use, and the powerful traveling crane installed in many shops until the demand for some intermediate apparatus became evident, some portable device, more powerful, more rapid, and of wider applicability than the chain block, and this demand has been met by the production of a machine which needs only to be hooked up and to have its wires connected to be ready for service anywhere where current is available.

One of the elements in high shop-efficiency lies in the proper use of just such a machine. It is poor management to take an expensive man to do the work which can well be performed by a boy or by a laborer, and it is equally poor management to use a heavy traveling crane for work which can be performed more effectively by the light and rapid electric hoist. Good management includes the proper distribution of effort, using the traveling crane for heavy loads; the electric hoists for lifting lighter pieces, for serving machines, and for assembling; and the small electric hoists or properly selected chain blocks for conveying small pieces, in all stages of manufacture.

Apart from the increase in capacity and rapidity in handling work by the use of such machines as the electric hoist, there is a marked economy in their application, even when compared with the cheapest hand labor.

The speed of the electrically-operated hoist is five to ten times that of the hand hoist, while the cost, both of installation and of operation, is but a fraction of that required for the large power crane. It is to the shop what the light cavalry is to the army; what the machine gun is to the artillery; what the scout cruiser is to the navy: a most effective auxiliary in the contest for efficiency in manufacturing.

System in Transmission Machinery

ONE of the ancient figures in mechanical practice has now about passed away, that curious individual known as the "millwright." He was the natural outgrowth of the idea that every part of an outfit had to be made to suit its particular place, and that things must be made to stay where they were put. His was the day of hand-worked, wooden gear-teeth, of built-up pulleys, of slow-running, massive machinery, of high costs and low efficiencies.

To-day the development of system in transmission machinery has attained an important position. High-speed shafting of standard diameters, accurate finish, and low frictional resistance, runs in universal ball-and-socket bearings, carrying balanced pulleys, and delivering power with a minimum of loss. Standardization of sizes enables all parts to be carried in stock, and permits elements made in various places to be assembled into an efficient installation without special work or elaborate preliminaries. The job of the ancient millwright is gone, and his functions have been replaced by the work of the manufacturer of modern transmission appliances.

The extent to which such standardization has been carried is hardly realized, except by those whose work brings them into immediate contact with it. Standard diameters for shafting are understood; the actual number of sizes required is limited, the methods of manufacture enable accurate gauges to be used, and the material is a commercial standard product. Couplings, hangers and bearings, while involving somewhat greater number of variables, are yet amenable to systematization in a manner intelligible to the layman. When we come to the subject of pulleys, however, it seems as if the possibilities for an infinite permutation would render it practically impossible to develop any kind of a system which could make them manageable. Diameters ranging from a few inches to several feet, varying by fractions of an inch, are necessary to provide for the speed ratios required by a wide variety of custom. Faces of pulleys also vary to meet the belt-widths demanded by the service. In addition to these two groups of changes appears the necessity of providing for shafts of diameters from the smallest to the largest, since the small pulley often has to go on the large shaft, and the large one on the small shaft.

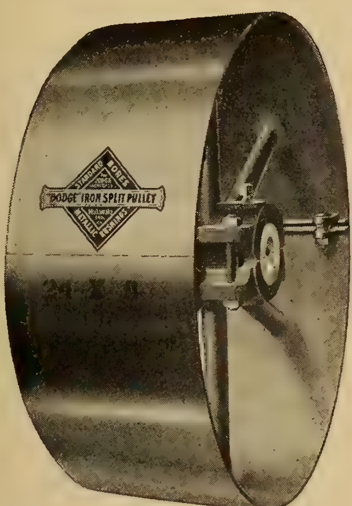
Any one who has ever considered the possibilities of such a compound series of permutations will realize the enormous number of elements required, and it might prove an interesting mathematical exercise to compute the warehouse space required to store even a reasonable stock of pulleys.

The difficulty of the problem has been much reduced by the introduction of the split pulley, although the original object in dividing pulleys in halves was to facilitate placing them in position upon shafting in use without taking down any portion, or removing other pulleys or couplings. The split pulley, in addition to its other advantages, has made it possible to employ a system of split bushings, these bushings being turned to a standard outside diameter, while the inside bore may be of any desired shaft size. By using the standard outside diameter of the bushings for a constant bore for all pulleys of the system, it has thus become possible to eliminate the difficult element of the variable bore, since a stock of bushings, requiring but a moderate space, enables any pulley of the system to be placed on any shaft throughout the range of commercial sizes.

To the old-time millwright the presence of a bushing in a pulley hub was an indication of a corrected misfit; to the transmission engineer of to-day it is the hall-mark of a most efficient system.

DODGE

Standard Iron Split Pulley



HERE is the pulley that power men everywhere are talking about — and thousands of them installing—because there is no other split pulley like it, no other that gives such positive, profitable service.

The Dodge Standard Iron Split Pulley is cast whole and the rim split by fracture at the parting lines, then bored, turned, ground and balanced.

Being perfectly balanced, when mounted on shaft by bolting the rim-halves together, it is *round* and *always runs true.*

Rim, arms and hub being integral and non-flexible, it *stays* round.

Fitted with interchangeable bushings, it fits any shaft.

Fastened to shaft by compression and the fastening anchored by two set screws—an exclusive Dodge idea—it *holds fast.*

The Dodge Standard Iron Split Pulley is made in standard sizes, from 6 to 54 inches in diameter.

Your orders will be filled immediately by mill supply dealers in almost every city, by one of our eight branches or direct from our factory. Write us for full and interesting information about better service and greater economy in power transmission.

Dodge Manufacturing Company

STATION H11 **MISHAWAKA, INDIANA**

Producer Gas Power

THE evolution of the modern gas engine is an interesting chapter of mechanical development. The early gas engines were almost toys, although they were much larger than the powerful little machines by which the modern automobile is propelled, and they developed but a few horse-power, while consuming expensive illuminating gas for their fuel. The real claim such machines had to economy lay in the fact that they ran only when power was wanted, and that they required little attention at any time.

As it began to be realized that the gas engine was in itself a most efficient machine, various methods were considered for providing a supply of fuel less costly than the high-priced illuminating gas, and then the discovery was made that a rich gas was by no means the most efficient fuel for a gas engine, but that a lean gas, having less than one-fourth of the calorific value of lighting gas, was capable of developing power in an internal-combustion engine at about one-half the cost in heat units required by the best steam engines. Closely upon this development came the discovery of the late B. H. Thwaite, that the waste gases of the blast furnace were available for direct utilization in the cylinders of the gas engine, and thus the new era in the generation of power from heat began.

Blast-furnace gases, after being cleaned from ash and dirt, form an excellent fuel for the gas engine, but there are many important departments of engineering work desirous of using gas engines for power generation which are without any such convenient source of gaseous fuel. For such requirements the gas producer has now become available.

Every one who has had occasion to use a hot-air furnace for the purpose of heating his residence during the winter months is familiar with the manner in which large volumes of gas are emitted when quantities of green coal are stoked into the fire pot upon a live bed of coals. The engineer has taken this simple arrangement and modified it so that the controlled combustion of the coal produces continually a flow of carbon monoxide, together with certain proportions of hydrogen, methane and similar combustible gases, mingled with the inevitable proportion of inert nitrogen, the whole forming a gaseous fuel, entirely suitable for use in the cylinder of the gas engine, and has thus provided for the gas engine what the boiler is to the steam engine, a source of latent energy, capable of development with a maximum degree of efficiency.

The importance of the development of such a complete system of power generation is as yet but imperfectly realized. This is largely because the gas producer and the gas engine as a whole have so recently come into the hands of the designing and manufacturing engineer. Producers are now built, however, which, when carefully operated, give good results in the hands of capable operatives, and it is well known that the gas engine has reached a high state of perfection, even in sizes of several thousand horse-power. In order that commercial success be attained, however, it is necessary that the entire plant shall be designed and installed under a single engineering supervision; that the various details of the system shall be fully adapted to each other, and that proper design in one element shall not be hampered and possibly discredited by defects in some other detail.

When it is considered that gas producers may be operated with a far greater variety of fuel than is available for the steam boiler, and that good fuel gas may be produced from coke, anthracite, bituminous coal, lignite, peat, wood, etc., it becomes evident that continuous success can be attained only by the combination of specialized engineering skill accompanied with extended experience; but when such a combination is available, the great advantages of gas power can be secured with almost any fuel, and for installations of any size.

Manufacturing News

An Interesting Storage Battery Truck

THE accompanying illustration shows a new yard truck just brought out by the Jeffrey Manufacturing Company, of Columbus, Ohio.

The electrical equipment, including storage batteries, motor, controller, with all necessary charging instruments, are all located below the platform so that the truck can be used for carrying material of any kind, or for hauling yard cars. The design is such that it can be used on any gauge from 18 inches up, and on the shortest curves encountered on industrial tracks. The electrical equipment is furnished in sizes to suit the service.

For loads up to 10 tons a 6-horse-power motor with 10-kilowatt battery is provided. For heavier service larger motors and batteries are supplied, depending on the maximum loads and the frequency of the trips. The platform is made removable, allowing easy access to the electrical equipment.

For the service usually encountered around the average manufacturing plant, moving raw material, castings, etc., the 6-horse-power equipment will operate two or three days on a charge.

By estimating the average weight and average length of trip the proper size equipment can be determined. The use of these cars facilitates the handling of material around a manufacturing plant, and also effects a material saving in the cost of this work.

NEW STORAGE BATTERY TRUCK. THE JEFFREY MANUFACTURING COMPANY, COLUMBUS, OHIO.

Allis-Chalmers Company

RECENT sales of Allis-Chalmers electrical apparatus, exclusive of combined generating units, which constitute a large list in themselves, include the following:

Merchants' Heat & Light Company, Indianapolis, Ind., two 1,000 KW. synchronous motor generator sets, 3-phase, 2,300 volts, 60-cycle, A.C., 250 volts shunt-wound D.C., and one 200 KW. shunt-wound balancing set, consisting of two 125-volt machines on a common cast-iron base; Delaware, Lackawanna & Western Railroad, Hampton Power Plant, Scranton, Pa., one 1,500 KVA, O.F.W.C., 3-phase, 60-cycle transformers, 4,150/2,200 volts; San Francisco Gas & Electric Company, San Francisco, Cal., two 1,000 KW. synchronous motor-generator sets, 3-phase, 11,000 volts, 60 cycles, A.C., 275-volt compound-wound D.C., Great Northern Railway Company, St. Paul, Minn., nine induction motors, aggregating 220 horse-power, 440 volts, 3-phase, 60 cycles; Joseph Light & Power Company, Joseph, Ore., one 225 KW. A.C. Waterwheel type generator, 2,300 volts, 3-phase, 60 cycles, with exciter and switchboard; Portland Railway, Light & Power Company, Portland, Ore., one 500 KW. vertical direct-current generator, 600 volts, with switchboard; Wind River Lumber Company, Cascudo Locks, Ore., one 100 horse-power induction motor, 3-phase, 60 cycles, 440 volts; Caldwell Milling & Elevator Company, Caldwell, Idaho, one 100 horse-power, 220-volt, 3-phase, 60-cycle induction motor; Pocahontas Consolidated Collieries Company, Switchback, W. Va., one 175 horse-power, 2,080-volt, 3-phase, 60-cycle induction motor; Toledo & Indiana Railway Company, Toledo, Ohio, one 400 KW. rotary converter, 500 R.P.M., 25 cycles, 3-phase, 600 volts D.C., with three 150 K.V.A. O.F.S.C. Transformers 3,200/375 volts, together with switchboard; Victor Talking Machine Company, Camden, N. J., eight type "K" motors, aggregating 530 horse-power, 220 volts D.C.; Goodyear Lumber Company, Tomah, Wis., 19 induction motors, aggregating 925 horse-power. Crane Company, Chicago, Ill., one 300 KW. synchronous motor generator set, 440 volts, 60 cycles, A.C. 250 volts D.C. and three 100 horse-power induction motors, 440 volts, 60 cycles; Great Western Power Company, San Francisco, Cal., 15 O.F.S.C. transformers, 22,000/2,400 volts, aggregating 2,100 K.V.A.; Milwaukee & Fox River Valley Railway Company, one 200 KW. 2,300 volt synchronous motor, 60 cycles; Diamond Match Company, Barberton, Ohio, 11 induction motors, aggregating 75 horse-power; Illinois Steel Company, Joliet, Ill., one 1,250 K.V.A. synchronous frequency changer, changing from 3-phase, 2,200 volts, 60 cycles to 3-phase, 6,600 volts, 25 cycles, 300 R.P.M., one 200 KW. synchronous motor generator set, 3-phase, 25-cycles, 6,600 volts, 2,200 volts D. C., together with switchboard; Cambria Steel Company, Johnstown, Pa., one 500 KW. rotary converter, 3-phase, 25 cycles, 575 volts D.C.; Pacific Lumber Company, Wilmington, Cal.

Recording Thermometers

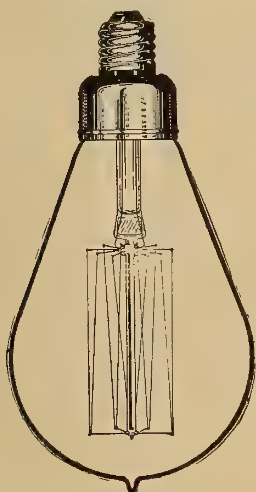
Referring to the advertisement of The Bristol Company, on page 3 of this issue of CASSIER'S MAGAZINE, we desire to call attention to the fact that the Bristol Recording Thermometers are adapted for the measurement of temperatures in all kinds of industrial operations, and that these recording thermometers are by no means special appliances designed merely for the record of feed-water temperatures.

The instruments manufactured by The Bristol Company now cover the requirements of every department of manufacturing industry, and from the fact that they furnish a continuous and indisputable record for precise periods of time, they eliminate all uncertainty, such as necessarily attaches to intermittent observations.

A New 150-Watt Tungsten Lamp

THE General Electric Company has just listed a new 100 to 125 volt Tungsten lamp. It is rated at 150 watts and supplied in 3⅜-inch pear-shaped bulb.

The lamp is designed to supply an intermediate unit between the 100-watt and the 250-watt types. Many central stations desire this lamp to replace gas arcs, for which the 100-watt lamp is too small and the 250-watt too large.



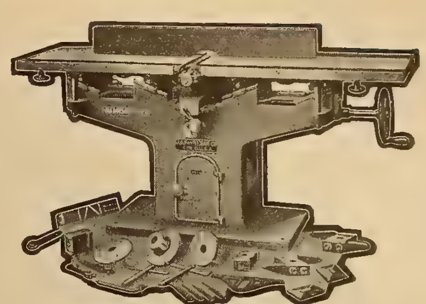
TUNGSTEN LAMP, 150 WATT.
GENERAL ELECTRIC COMPANY.

This new lamp has all the well-known and superior characteristics of the G. E. Tungsten lamp—the same excellent method of mounting and the special anchoring support for the filament, which insures a maximum of mechanical strength and ability to withstand usage and permitting its satisfactory operation in any position.

Information concerning prices, etc., may be obtained from any of the offices of The General Electric Company.

The Universal Woodworker

ON this page is illustrated a Universal woodworking machine. The variety of work that can be done on this machine is practically unlimited. It is so readily adapted to so many kinds of work that a skilled operator will find difficulty in trying to exhaust its capacity. Indeed, the variety of work it will do warrants the manufacturers in styling it "A Whole Wood Shop in Itself."



UNIVERSAL WOODWORKER. J. A. FAY & EGAN COMPANY, CINCINNATI, OHIO.

The following are some of the things that can be done on it: Plane out of wind, surface straight or tapering, rabbet door frames, joint, bevel, gain, chamfer, plow, make glue joints, raise panels either square, bevel or ogee; work circular mouldings, etc.; rip, cross-cut, tenon, bore, route, rabbet, work edge mouldings, etc.

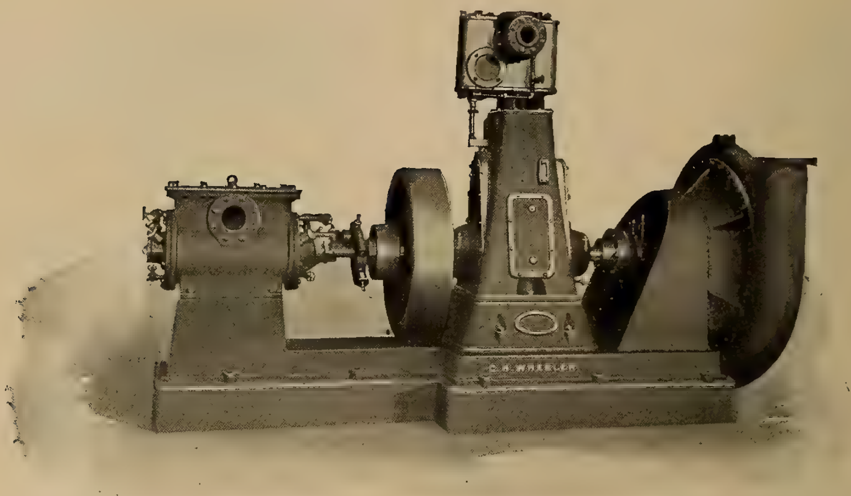
It would pay an importer of machinery products to carry in stock at least a half dozen of these machines.

For further information you are requested to write the manufacturers at 226-246 West Front street, Cincinnati, Ohio, who will be pleased to take the matter up with you immediately.

Rotrex High-Vacuum Air Pump

THE steadily-increasing demand for higher economy of steam prime movers which has been accompanying the development and application of steam turbines during the past few years made a simultaneous advance in the design of condensing apparatus necessary.

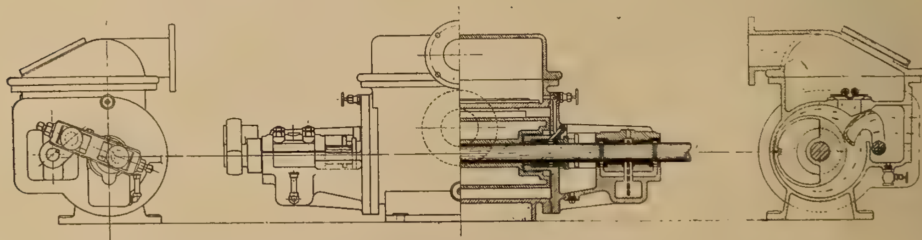
Guided by such consideration the C. H. Wheeler Manufacturing Company, of Philadelphia, succeeded in developing a new type of rotary air pump embodying all the essential features of a high-grade and high-vacuum air pump, occupying but a fraction of the space necessary for any other type of pump, with the additional advantage of being adapted for direct connection to another



ROTREX AIR PUMP DIRECT-CONNECTED TO STEAM ENGINE. C. H. WHEELER MFG. CO., PHILADELPHIA, PA.

auxiliary. The accompanying cut illustrates one of the standard arrangements, consisting of vertical high-class steam engine direct connected to a Rotrex air pump on one side and a centrifugal circulating pump on the other. By this arrangement, the one engine driving both pumps, the speed of the combined outfit being from 180 to 250 R.P.M., according to the size of the unit, the gain will be obvious to all engineers—eliminating, as it does, the additional steam cylinders ordinarily used to drive the air pump.

The construction of the Rotrex pump (see the accompanying cross-section) is very simple, consisting of a light-weight cylindrical casing, one rotor eccentrically mounted on a heavy steel shaft carried in outboard ring-oiled bearings independent of the stuffing boxes. Division between the suction and discharge in the pump cylinder is made by means of a radius cam, which is carried in independent bearings, and is operated by means of a lever and crank from the rotor shaft on the outside of the pump. By this arrangement internal contact, which has been the cause of the failure of practically all the rotary pumps ever devised, is entirely eliminated; the rotor operating with a close clearance from the bore of the pump cylinder and the cam maintaining a close clearance from the rotor. The clearances, by an ingenious arrangement of ports, are thoroughly water sealed at all times, *i. e.*, the pump relies on water-sealed clearances to produce the high



SECTIONAL VIEWS OF THE ROTREX HIGH-VACUUM AIR PUMP. THE C. H. WHEELER MFG. CO., PHILADELPHIA, PA.

vacuum obtained, and not on surface contact or sliding fits. The other notable feature of the pump is a special arrangement of metallic discharge valves, no suction valves being used, thus expensive upkeep is practically eliminated.

A long series of exhaustive tests, as well as performances of a number of pumps installed in various power plants and giving most satisfactory results, have established the Rotrex pump as being qualified in every respect to maintain the highest vacuum.

Due to the high speed, the overall dimensions are very small, which fact will be appreciated from the cut showing the proportionate size of the air pump as compared to the circulating pump and driving engine.

The pumps are being manufactured in capacities from 50 to 5,000 horsepower in one unit; beyond that size multiple units are used, an independent air pump engine having one Rotrex pump direct connected to each end of its crank shaft.

An Improved Bending Machine

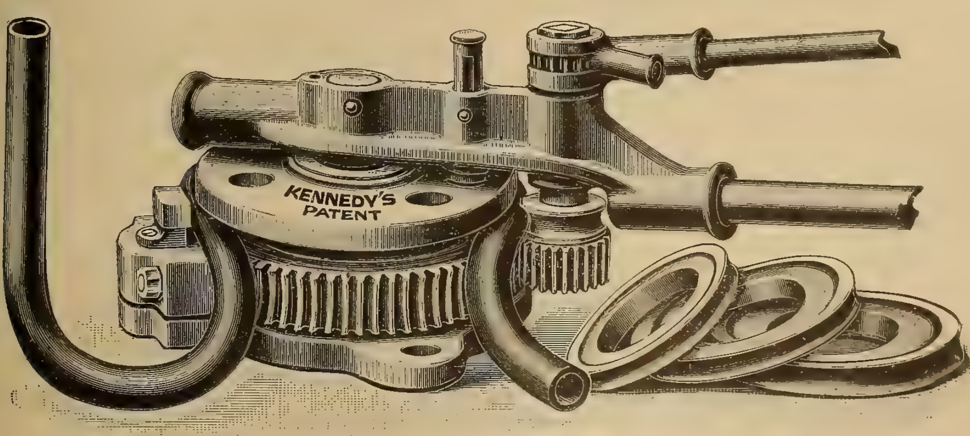
EVERY steam fitter realizes the value and importance of the convenient pipe-cutting and threading machines which are now made in portable form and which can be carried out and set up for immediate use upon the place where the job is being performed. We illustrate herewith a companion apparatus, the Kennedy bending machine, by the use of which any desired number of bends may be made at any angle and in any position on long lengths of work.

This machine does away with stock elbows, bends and sockets to a large extent, also saving a large amount of cutting and screwing, and reducing the possibility of leaky joints. It is adapted for bending welded, butt-joint and seamless pipe, also round, flat, angle, tee, and channel bars, in copper, brass, iron and other metals.

The general construction of the machine is clearly shown in the illustration, and its wide applicability will be evident to every one familiar with the demands of the steam and pipe fitter.

Full information concerning this useful tool may be obtained by communicating with the Kennedy Bending Machine Company, care of the Business Development Company, 36 Upper Thames street, London, E. C., England.

THE BRISTOL COMPANY, of Waterbury, Conn., have just established a branch office at Pittsburg. This is located in the Frick Building Annex, and an expert



BENDING MACHINE. THE KENNEDY BENDING MACHINE CO.

will be located there to co-operate with customers whose plants are in the immediate vicinity of Pittsburg, including Newcastle, Youngstown, Wheeling, Scottdale, Johnstown, and Oil City.

The Bristol Company are making a specialty of studying the application of their recording instruments in many different industries. For instance, they have specialized in recording instruments for blast furnaces, including recording pressure gauges for hot blast, top gas and steam; electric pyrometers for hot-blast temperatures, top-gas temperatures and general tests; electric time recorders for recording the movements of rotary top, skip hoist, large bell, small bell and gauge rod; recording thermometers for Gailey dry-blast temperatures, condenser water temperatures, feed-water temperatures, etc.

Besides the blast furnaces in the Pittsburg district, there are many other processes in connection with which the use of Bristol's recording instruments has become very important, and the applications have been studied so carefully that the company is prepared not only to recommend and furnish the most suitable recording instruments but also to have their own representative superintend the installation of these in their customers' plants.

The Philadelphia Bourse

WITH the increasing certainty of a revival in business, the various methods of obtaining effective publicity necessarily come before the progressive manufacturer for consideration. Among these methods, that afforded by the exhibition department of the Philadelphia Bourse demands attention on account of the peculiar advantages which it offers.

The opportunity of showing machinery in actual operation is often most valuable, and at the Bourse this is provided in connection with office facilities.

The extent to which publicity is obtained in the exhibition department of the Bourse will be realized when it is stated that an average of 1,332 people pass through the hall from 8:30 in the morning until 5 o'clock in the evening. These passers represent people interested in manufactures, commerce and industry, the very class of people attracted by mechnical appliances, and in a position to become customers. To receive them there are not only the representatives of the exhibitors, but the officers of the exhibition, ready to answer questions and give information.

Among departments of manufacture which have received very satisfactory results for the use of the exhibition department of the Bourse may be mentioned the gas and gasoline-engine industry. Among the manufacturers of marine engines of this kind which find the use of the Bourse satisfactory there are the Jager, Bridgeport, Mianus, Hall, Palmer, Niagara, Ferro, Atlantic, Buffalo, Gray, Standard, Sterling, Barber, Stanley, Oriole, and Hettinger. Among stationary engines of this type are included the Otto, Alamo, Kenton, Mietz & Weiss, and Hornsby-Akroyd.

The presence of these engines, together with steam engines in operation, as well as the availability of a supply of electric current, enables any exhibitor to obtain power for the operation of machinery.

It is evident, therefore, that for many departments of commercial enterprise, especially in connection with the demonstration and sale of machinery, the Philadelphia Bourse, in its exhibition department, provides a most effective sales medium.

Communica'ions relative to space in the Bourse may be addressed to the Superintendent of the Exhibition Department, The Bourse, Philadelphia, Pa.

Nsws Items

The contract for the construction of a hydro electric development across Paulin's Kill, Columbia, New Jersey, for the Warren County Power Company, Meikleham & Dinsmore, engineers, has been awarded to Frank B. Gilbreth, 60 Broadway, New York City.

This contract includes the construction of a Ransom hollow dam 30 feet high and 350 feet long, as designed by Ransom & Hoadley, of Providence, R. I., a reinforced concrete power house and a tailrace, etc.

Mr. H. G. Nicholls, who has for several years been assistant general manager of the Canadian General Electric Company and the Canada Foundry Company, has resigned the position in order to go into business for himself. He has organized a company called "Factory Products Limited," with offices in the Confederation Life building, Toronto, for the purpose of acting as Canadian selling agents for representative manufacturers.

The *Technical Index,* a comprehensive record of current technical literature published in Belgium, announces that hereafter it will be represented in the United States by the Geo. H. Gibson Company, Tribune building, New York City. The *Technical Index* appears monthly and gives a systematic descriptive record of all original articles appearing in over 200 engineering and technical journals and reviews, also indexing the proceedings of technical societies and technical books issued in all countries. The method of indexing covers the name of the author, the title of the article in full, an explanatory note stating the contents of the article, the name and date of the publication in which the article appeared and the length of the article. Two editions are printed, one upon both sides of the paper and one upon one side only for card index purposes and for further convenience; all items are arranged according to the Dewey decimal system. Clippings or copies of articles, also books, are supplied by the publishers of the *Index,* the price being indicated in each case. It is stated that over 1,000 original articles are indexed each month, covering all lines of engineering and technology. The American agents offer to send free sample copies upon request and will also receive orders and subscriptions.

The Cutler-Hammer Manufacturing Company, of Milwaukee, makers of electric controlling devices, announces the opening of a Philadelphia office, Room 1,207, Commonwealth building, and an engineer specially qualified to advise regarding the control of electric motors will be in charge of the new office.

In order to meet the requirements for space resulting from the merging of The American Trust & Savings Bank and the Continental National Bank, H. M. Byllesby & Co., Chicago, have vacated the fifth floor of the American Trust Building on Sunday, August 1, to enable the merged banks to occupy this space to accommodate a part of their clerical force, and H. M. Byllesby & Co. have on that date opened temporary offices in the Banking rooms at the corner of Dearborn and Monroe streets, formerly occupied by the Commercial National Bank.

On October 1, H. M. Byllesby & Co. will move to the Banking rooms at present occupied by the Continental National Bank, and will remain in that location until they return to the American Trust Building on June 1, 1910.

These removals are brought about solely for the purpose of accommodating the merged banks, whose business demands possession of the fifth floor of the American Trust Building, which has been occupied by H. M. Byllesby & Co. from the opening of the building to the present time.

At the recent annual meeting of the stockholders of the Wheeler Condenser & Engineering Company, held at their Works, Carteret, N. J., Mr. J. J. Brown, M. Am. Soc. M. E., was elected vice president and general manager. Mr. Brown entered the condenser field some 15 years ago as Southwestern manager for the Henry R. Worthington Company, and later became their general sales manager. After the formation of the International Steam Pump Company he became their general Western sales manager, with headquarters at Chicago, and resigned that position to take up his present work. The Wheeler Condenser & Engineering Company has recently introduced several important improvements in condensing apparatus, among which are the "dry-tube surface condenser," which has shown remarkable results in high vacuum work. The company has also in hand new and improved types of rotative dry vacuum pumps, centrifugal pumps, centrifugal jet condensers and cooling powers. The plant at Carteret, N. J., is being enlarged and improved. Among these improvements is a new power house, which will be equipped with several different systems of condensers for exhibition purposes, as well as for supplying the electrical energy which will be used throughout the shop.

The contract for building 1,000 feet of reinforced concrete docks for the Deering works of the International Harvester Company, of Chicago, has been awarded to the Raymond Concrete Pile Company, of New York and Chicago. The decks are located along the north branch of the Chicago River.

A 2,500-kilovolt-ampere Westinghouse alternator, driven by a 2000-kilowatt Westinghouse steam turbine, has been ordered for furnishing light and power service to the Erwin Cotton Mills at West Durham, N. C. The steam element operates at 175 pounds pressure and exhausts into a vacuum of 27 inches. The power distribution will be made with three-phase, 60-cycle current at 600-volts. This property is the largest among the great cotton-mill interests of the Dukes, of the American Tobacco Company.

For the purpose of forming an organization of wider scope and greater strength, Benjamin R. Western and W. Hull Western, until August 1, 1909, respectively proprietor and manager of the Manufacturers' Advertising Bureau, 237 Broadway, New York, and Walter Mueller and W. H. Denney, until August 1, 1909, respectively president and treasurer of The Banning Company, 225 Fifth avenue, New York, have organized the Manufacturers' Publicity Corporation.

The officers of the corporation are Benjamin R. Western, president; Walter Mueller, vice-president and general manager; W. H. Denney, treasurer, and W. Hull Western, secretary. The officers are located at the Hudson Terminal Building, 30 Church street, New York; telephones 474 and 475 Cortlandt. The advertising interests of the clients heretofore directed by the aforementioned will henceforth be in charge of the Manufacturers' Publicity Corporation.

Mr. E. W. Carter, who has for some time past been in charge of the Boston office of the Hoyt Electrical Instrument Works, will hereafter be connected with the factory, and Mr. A. K. Brown will succeed him in charge of the Boston office. Mr. Brown has been identified with Hoyt instruments for a considerable time, and is therefore well equipped for his new position.

The Phosphor-Bronze Smelting Company, of Philadelphia, have issued notices stating that they have acquired all the property of The Phosphor-Bronze Smelting Company, Ltd., and that they will discharge all the obligations and liabilities of this company and carry on the same business formerly conducted by it.

THE LATEST CATALOGUES

Pumps

C. H. Wheeler Manufacturing Company, Philadelphia, Pa. Bulletin No. 10 illustrates the most recent developments in pumping machinery. This company manufactures steam, electric and power-driven pumps, both for pressure and vacuum.

Beam Shears

The Watson-Stillman Company, New York. Catalogue No. 74, which is the latest publication of this company, describes their new hydraulic beam shear, a most practical machine for cutting I-beams, channels, tees, flat bars, angle irons, corrugated channels, Z-bars, and other structural shapes. The Watson-Stillman hydraulic coping machine for trimming structural shapes, small pieces of plate metal, bar iron, etc., is also illustrated.

Gauge Boards

American Steam Gauge and Valve Manufacturing Company, Boston, Mass. This company have recently issued a pamphlet covering engine-room gauge boards. These boards are furnished in any kind of marble or slate for any number of instruments. Plain and fancy boards of oak, black walnut, cherry, mahogany and cast iron are also furnished.

Propeller Fan

The Jeffrey Manufacturing Company, Columbus, Ohio. The Jeffrey Propeller Fan is something new in mine ventilation, and a distinct improvement over anything which has heretofore appeared. It is described and illustrated in bulletin No. 23.

Locomotives

Burnham, Williams & Co. (Baldwin Locomotive Works), Philadelphia, Pa. Illustrated catalogue of locomotives and detail parts. A very interesting historical sketch of the works and the development of the Baldwin Locomotive is given as an introduction to the book.

Gas Producers

The Morgan Construction Company, Worcester, Mass. High-class publication illustrating the Morgan continuous gas producer. Results of tests, analyses of gases, etc., are also contained in the catalogue.

Injectors

William Sellers & Co., Philadelphia, Pa. Handsomely illustrated catalogue treating of locomotive injectors and boiler attachments.

Electrical Measuring Instruments

Weston Electrical Instrument Company, Newark, N. J. Catalogue No. 15 is a handsome publication and is divided into four parts. Part I. describes portable D.C. instruments; Part II., standard portable instruments for A.C. and D.C., Part III., switchboard instruments, and Part IV. is a condensed supplement of dimensions and prices of Weston station instruments.

Separator

Potter Separator Company, Newburg, N. Y. Catalogue describing the Potter Mesh Separator. This apparatus separates the moisture from the steam at the outlet of the boiler, and delivers dry steam to the pipe, thus preventing accidents to the engine due to watershock.

Electrical Power for Domestic Purposes

The Westinghouse Electric & Manufacturing Company, Pittsburg, Pa., has prepared an attractive little folder having the above name. Among the labor-saving applications of electric power noted in it are the sewing machine, vacuum cleaner, washing machine, ice-cream freezer, coffee grinder, meat chopper, ironing machine, silver polisher, dish washer, and the motor-driven pump.

Book News

Hydro-Electric Developments and Engineering

A Practical and Theoretical Treatise on the Development, Design, Construction, Equipment and Operation of Hydroelectric Transmission Plants. By Frank Koester. Size, 7½ x 8½ inches. 454 pages, with 500 illustrations. New York: D. Van Nostrand Company. Price, $5.00.

Believing that the progress in hydraulic engineering is stimulated by the interchange of American and European ideas, and having had considerable practical experience, both here and abroad, the author presents this volume as comprehending the most advanced American and European practice, and trusts that numerous novel features of hydraulic, mechanical and electrical engineering are made obvious.

It is not the object of the engineer as a designer of hydraulic developments to design any particular machine, such as a turbine, generator, transformer, etc., but to provide, by selection from the different makes, an assemblage of machines and devices, each designed to perform its particular function in the most economical manner, and to have the machines properly combined to form one complete unit for the purpose of generating and transmitting electrical current from water power on a satisfactory commercial basis. As a good illustration may tell more at a glance than a long discussion, numerous cuts are presented to readily show the present standing of the American and European Hydro-electric Engineering. Reports, maps and charts on rainfall, evaporation, and run-off may be directly acquired from the various governments, and therefore are not given,

As engineers, students, and others desire suggestions and examples in the same or similar lines of work as executed by engineers of standing, there are given in Part III. descriptions of several hydro-electric developments, distinctive in their individual features. From these the experiences and opinions of various authorities and examples of their works are given; for instance, the Niagara, Lockport and Ontario Power Company's development is an epitome of papers by five authorities.

It is hoped that the engineer in general, architect, and student, also the manufacturer, promoter, and financier will find in the text and illustrations a systematic and comprehensive treatise on hydro-electric plants from their inceptions to the delivery of power to the substation and consumer.

Gold and Silver

A Treatise on Gold and Silver. By Walter R. Crane, Ph. D., Instructor in Mining, School of Mines, Columbia University. Size, 6 x 9 inches. 727 pages, illustrated. New York: John Wiley & Sons. Price, $5.00.

The preparation of an economic history of the precious metals, gold and silver, involves the consideration of a number of subjects, if the record is to be complete. Among the subjects discussed in this connection are the occurrence, both geographical and geological, association, production of gravels and ores, and methods of mining and extracting of values. As the history of the precious metals, including the discoveries of deposits and the industrial activities resulting therefrom, is necessarily of prime importance in a work of this character, its treatment has been broad, and it has been approached from practically every side. In the chapter of the history of the precious metals, a detailed account is given of the discovery of occurrences of metals and ores throughout the United States, the period covered from the earliest known records, including legends up to the present time. This account has been further supplemented by a tabulated list of first discoveries, by whom and when made, and finally an extended chronology of the economic history of gold and silver mining is given.

The object of this work, with others of a series, is to give a complete and accurate record of the development of the mineral resources of the country and its influence on the various industrial activities throughout the United States.

Locomotives

Locomotive Engine Running and Management. By Angus Sinclair. Size, 5 x 7 inches. 438 pages, with 55 illustrations. New York: John Wiley & Sons. Price, $2.00.

This is the twenty-second edition of a book showing how to manage locomotives in different kinds of trains with economy and dispatch; giving plain descriptions of valve gears, injectors, brakes, lubricators and other locomotive attachments; treating on the economical use of fuel and steam, and presenting valuable directions about the care, management and repairs of locomotives and their connections.

The last chapter of the book contains a catechism for the examination of engineers and firemen.

Induction Coils

The Design and Construction of Induction Coils. By A. Frederick Collins. Size, 6 x 9 inches. 258 pages, with 155 illustrations. New York: Munn & Co. Price, $3.00.

The art of coil making has been developed to a remarkable degree of perfection chiefly by the empirical methods employed by professional artisans, and while all of the theoretical data provided by physicists are easily enough obtainable, the actual processes of construction, in accordance with modern practice, have not been hitherto available.

The present work treats of eight different sizes of coils, varying from a small one giving ½-inch sparks to a large one giving 12-inch sparks. These various-sized coils are included in three specific designs, and the author has tried to tell in easily comprehensible language each process in sequence, together with dimensions of each part down to the smallest screw.

Books Received

Pumps. $1.00. By Hubert E. Collins, New York: Hill Publishing Co.

Lecture Notes on the Theory of Electrical Measurements. Price, $1.00. By W. A. Anthony and A. Ball. New York: John Wiley & Sons.

Principles of Mining. Price, $2.50. By H. C. Hoover. New York: Hill Publishing Company.

Light and Sound. Price, $1.60. By Wm. S. Franklin and B. Macnutt. New York: The MacMillan Company.

Descriptive Geometry. Price $2.00. By G. C. Anthony and G. F. Ashley. Boston: D. C. Heath & Co.

Practical Testing of Gas and Gas Meters. Price, $3.50. By C. H. Stone. New York: John Wiley & Sons.

Mechanical Drawing and Machine Design. Price, $3.00. By J. S. Reid and D. Reid. New York: John Wiley & Sons.

Development and Electrical Distribution of Water Power. Price, $3.00. By Lamar Lyndon. New York: John Wiley & Sons.

The Economy Factor in Steam Power Plants. Price, $3.00. By G. W. Hawkins. New York: Hill Publishing Company.

Experimental Electrical Engineering. Price, $6.00. By V. Karapetoff. New York: John Wiley & Sons.

The Portland Cement Industry from a Financial Standpoint. Price, $2.00. By E. C. Eckel. New York: Moody's Magazine.

Steam Turbines. Price, $1.00. By Hubert E. Collins. New York: Hill Publishing Company.

Gas Engine Theory and Design. Price, $2.50. By A. C. Mehrtens. New York: John Wiley & Sons.

The Bell Telephone. The deposition of Alexander Graham Bell in the suit brought by the United States to annul the Bell patents. Boston: The American Bell Telephone Company.

Society for the Promotion of Engineering Education. Proceedings of the sixteenth annual meeting. Volume XVI., Brooklyn, N. Y. Office of the Secretary Pratt Institute.

Power Handling Machinery

IT is a curious example of the transformation in the meaning of words that the term "handling" should have gradually come to mean dispensing with the labor of human hands, just as the word manufacturing now signifies precisely the opposite what is indicated by its etymology, and means that the "manufactured" article has been produced by the use of mechanical appliances, as opposed to the hand-made product.

Doubtless the very oldest form of human labor was that involved in the digging of the ground. Appearing first in agricultural operations and in the necessary work of the cultivation of the soil, it soon extended to mining work, and the digging of ores and useful materials from the hillsides and from beneath the surface of the earth formed both early and laborious human occupations.

Although man gradually learned to bring the effort of the ox and the horse to his aid in some departments of this heavy burden, it was not until the development of steam power that he was able to secure any substantial relief. Then, and not until then, was he able to extend his operations far into the depths of the earth, and it is noteworthy that the first, and for a time the only work accomplished by the steam engine, was in connection with mining.

After the introduction of steam locomotion, and even down to the present time, one of the most important departments of railway traffic appeared in the hauling of coal and ores from the mines to the locations where their value could be utilized, and thus the "handling" of coal and ore became still further extended.

In more recent times the applications of machinery to the relief of manual labor in the transport of coal and ore appears in the modern handling appliances, to be seen at many of the wharves, docks and power houses. The old-time laborious shoveling is conspicuous by its absence and instead is seen the combination of elevators, conveyors, cableways, railway systems and bins, taking the material from the holds of vessels and raising, transferring and delivering it wholly by mechanical power, directed by human intelligence, and yet in large measure automatic.

When the enormous extension of power machinery is considered, it will be seen that modern power plants could hardly have come into existence if the handling of the fuel had been dependent upon unaided human muscle. The great steamships, it is true, still require large numbers of stokers to feed the boiler furnaces, but apart from these exceptions, the reception, storage and delivery of coal to the boiler furnaces of power plants, at least in the larger installations, is effected almost wholly by machinery. The same is true of the tremendous development of iron manufacture. Here the use of machinery is even more highly organized. The ore is taken from its bed by steam shovels, delivering it directly into the cars in which it is hauled to the docks, and from which it is mechanically loaded into the holds of the vessels by which it is transported to the ports, where it is again transferred either to cars, or by means of especially ingenious buckets and conveyors delivered to storage bins. Again, either by mechanism or by gravity it is transported to the furnaces and raised, almost continuously, to the top, hand hardly having been lifted in the course of the whole operation from mine to furnace, except to guide, control and direct the machinery.

Such appliances have been described as "labor saving" machinery, but to a large extent the work which they perform is labor which could never have been accomplished at all by hand. Rather are they to be called "labor making" machinery, since the result of their introduction has been to create fresh opportunities for labor of a far higher class, both in their use and in the establishments in which they are themselves manufactured.

The Transmission of Power

MUCH attention has been paid to the generation of power, and whether the prime mover be a steam engine or a water wheel the question of its efficiency has attracted the attention of the engineer almost from the times when man first began to harness mechanical forces and utilize them to do his work. The result has been a marked improvement in the performance of both engines and water wheels, a natural consequence of the maintenance of records and the comparison of performances. The Cornish pumping engines, in the days of Watt and his associates, were in continual competition with each other, and the result was a performance which was surpassed only within recent days, while the tests of turbine water wheels developed under the auspices of Swain, Francis, and their successors produced wheels which gave efficiencies so high that but a small margin remained available for improvement.

Power, however, is of little use until it is delivered to the machinery by means of which it is to be converted into remunerative mechanical operations. The lathe, planer and shaper must be driven from their countershafts, and these again must receive their motion from the line in the room in which they are placed, and thus, until the origin of power is reached there extends a line of transmission, involving shafting, hangers, pulleys, belting, clutches, etc., all costing money and consuming power, and forming a portion of the plant involved in the manufacture of the product. The active losses in this service of transmission must be remembered; the wear and tear upon its details must be considered as forming elements in the depreciation charges which the equipment must earn and which must be paid for, and it is only the net result delivered to the operative tools which produces results, and which can be considered as a gain and not as a loss.

Until comparatively recently this element in the cost of manufacturing operations has been given scant consideration. The engineer has expended much time and labor to secure a fractional gain in the efficiency of the prime mover, when, at a much smaller cost he might have made a far higher economy in the transmission end of the problem, and have reduced the expense of the finished product proportionally.

That there is a necessary loss in the transmission of power from engines to machinery must be admitted, but this loss can be reduced to a minimum only by the combination of close attention united with long experience in this particular department of engineering.

Thus, the choice of method of transmission, whether by shafting, belting, rope drive, or electric current, must depend upon local conditions and upon the nature of the work and the tools by which it is to be performed. The frictional losses are governed largely by the method of lubrication, by the distribution of weights, by the opposing tension of belts, and by the maintenance of alignment. The efficiency will depend upon the selection of the proper rotative and lineal velocities, upon the direction of forces, and upon the location of machines. What is right for one place will be wrong for another, and unless to a knowledge of fundamental principles there is brought the accumulation of a ripe experience, it may be found that all the efficiency secured in the generating end of the plant is lost in the transmission service.

It is an accepted principle in efficiency that the ultimate result is the continued product of the efficiencies of the several elements of which the whole is composed. This means that what is gained at one point may be very easily lost at several others, and that a high efficiency of the whole can be attained only by securing the maximum result in every detail.

One of the points in which there is room for improvement in many shops, lies in the power transmsision department, a department too often neglected.

Mr. Power User, You Need This Magazine —and The Coupon Brings It To You— Free

POWER TRANSMISSION is a vital problem which every Power User must face.

Is your Power Transmission "just right?" Can you answer that question frankly in the affirmative, without hesitation, and say that you have the least possible waste of power from engines to machinery?

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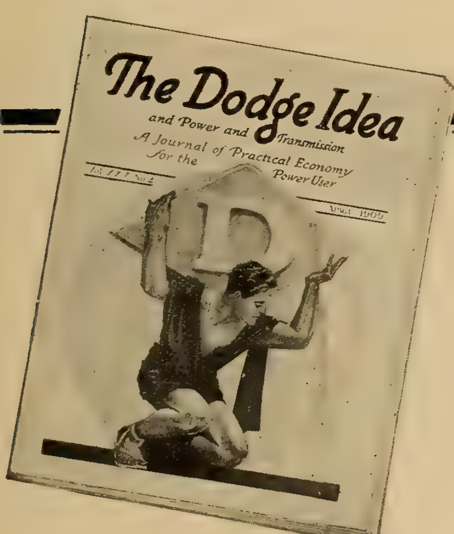

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Simplification of Mechanical Appliances

IT is an interesting fact that the inventor and designer, however experienced, nearly always produces his first attempts for any improved machine in a more complicated and intricate form than is afterwards found necessary or desirable. Parts which at first seemed indispensable are discovered under the test of actual experience to be capable of great simplification or may, perhaps, be altogether omitted. Movements which may have charmed the engineer by their ingenuity and accuracy are soon found to lack durability or to be actually unnecessary. Considerations derived from experience in the shop as to the economical manufacture of parts begin to have their influence upon the whole apparatus, and when the machine takes its place as an article of commerce, adapted alike to the shop in which it is made and the establishment in which it is to be used, it is generally found to have become far simpler than the original designer would have admitted to be possible.

An excellent example of this course of development appears in the application of electric power to hoisting machinery. Some of the earlier electric hoists were designed without a full familiarity with what had already been accomplished in the department of hand-operated chain hoists.

As a matter of fact, the chain hoist had already been developed from the first ingenious differential block of Weston, through the improved screw block, to the perfected Triplex block, a device attaining practically a maximum efficiency, while, at the same time, including the balance of effort and perfection of control not otherwise attainable.

The Triplex block, however, was a hand-power appliance, and for many purposes a power machine was found desirable. Instead of proceeding to recast the whole machine, the far simpler plan was followed, and to the spur-gear system, with disc friction brake, of the Triplex block, there was added an electric motor, converting it, without further complication, into an electric hoist.

Let us suppose, instead of this simple and effective contrivance, that the inventor had set out to make an electric hoist without taking into account the ingenious and successful methods which had already been employed to secure the highest practical efficiency and convenience with hand-operated chain blocks. It is almost certain that he would have produced a machine with many more parts and with fewer conveniences; a machine which would have been more expensive to manufacture and less satisfactory to use; a machine which, after considerable expenditure and experience, he would have modified by eliminating the unnecessary members.

An efficient and convenient electric hoist being once provided, its applications become obvious and numerous. By the addition of overhead tramway, or by the use of a light hand traveler, the electric hoist becomes extended into a means of transport as well as a device for lifting. In many shops it may be installed at points where power handling can be foreseen and yet where the use of a power crane is impracticable. The mere possession of the combination of hoisting mechanism and electric power suggests applications which might otherwise have been considered impracticable; leading, in many cases, to reduction in laboring force, and often rendering possible rearrangements of methods of handling work.

It is by such combinations of well-established elements that some of the most effective devices have been produced for various departments of work, each designer availing himself of the perfected efforts of his predecessors to create new assemblages of mechanical devices for extended capacities and uses.

Manufacturing News

Handling Crushed Stone

FOR the Tide Water Broken Stone Company, at Quincy, Mass., the Dodge Manufacturing Company installed, some time ago, a conveyor and elevator equipment which has proved a decidedly good investment as a system for handling crushed stone under peculiar conditions.

The stone plant, as the company's name indicates, is located at tidewater, where a long stretch of grass-grown flats—dry at low tide and flooded at high tide—must be crossed in reaching the navigable water. The Dodge equipment includes not only the conveyor across the tide flats, but also the elevating and conveying machinery for handling the stone to and from the plant and for unloading it from the scows in making deliveries to purchasers.

Rock is brought to the plant in cars, which dump it into the boot of the bucket elevator leading to the top of the crusher house. From the crushers four conveyors carry the stone of different grades to four storage hoppers, from any one of which it may be loaded onto the long belt for transportation to the water front.

The main conveyor is 338 feet long, running on the level for about 210 feet and then ascending an incline to reach a height 20 feet above the level portion. This elevation enables the conveyor to discharge directly into the highest boat at flood tide. The belt is 16 inches wide, and is carried on Dodge standard self-oiling roll stands. The upper or load run is troughed, to increase its carrying capacity and prevent spilling. Side rolls at suitable intervals keep the belt in line. The return run of the belt is underneath, carried flat on straight rolls. The conveyor as a whole is supported above high tide on suitable piling and cross beams.

The company has two scows. Each is fully equipped, not alone for unloading its own cargo of stone, but also for self-propulsion in modest fashion. A 12 horse-power gas engine furnishes the power, which is transmitted through clutches to the stone-handling machinery or to the propeller.

Lengthwise through the bottom of the scow runs a 16-inch belt conveyor, to which the entire cargo of stone can be fed and by which it is taken to the elevator tower at one end. Here a bucket elevator takes the stone to the top of the tower, whence it may be distributed through spouts to vessels, cars or wherever wanted.

When installed, about two years ago, this was a new departure in methods of handling, transporting and delivering stone. It has proved very

satisfactory in all ways, and has enabled the Tide Water Company to conduct its business very much more expeditiously and cheaply than any of its competitors, none of them having any such mechanical equipment to facilitate the work.

The Dodge Manufacturing Company has orders in and quotations out on several installations of similar character for other concerns which furnish broken stone for all classes of work.

A new quick-reading form of the Wm. H. Bristol pyrometers has been designed and preliminary models tested in actual service in several different processes where the temperatures are excessively high and the requirements very severe. This special pyrometer consists of a patented compound thermo-electric couple used in connection with a special portable instrument equipped with a pivot jewel bearing Weston movement. The complete outfit is shown in Fig. 1.

FIG. 1.—THE WM. H. BRISTOL PORTABLE ELECTRIC PYROMETER FOR THE QUICK READING OF HIGH TEMPERATURES, MADE BY THE BRISTOL COMPANY, WATERBURY, CONN.

The Bristol Portable Electric Pyrometer

THE Wm. H. Bristol electric pyrometers have become well known in many processes where temperatures lower than 2,000 degrees are used. These pyrometers have been made in both switchboard and portable form to indicate or record high temperatures, but most of the instruments now in service are for ranges of temperature lower than 2,000 degrees. There are quite a number of processes in which excessively high temperatures are used, and these temperatures should be measured intermittently in order to make control possible and to obtain a uniform product. In experimental work temperatures in the neighborhood of 2,500 deg. F. should often be measured, as, for instance, in boiler tests where the boiler furnace temperature is to be determined.

The thermo-electric couple is shown externally in Fig. 2. Fig. 1 shows the couple with the protecting sheath pulled back against a stop, leaving the tip of the thermo couple exposed. When a reading is to be taken with this special thermo couple it is inserted into the furnace or kiln, as shown in Fig. 2, with the tip protected from mechanical injury, and as soon as the couple has been inserted at the proper point in the kiln the iron pipe protecting sheath is slipped back so that the tip is exposed to the hot gases whose temperature is to be measured. After a reading has been taken the couple should be quickly withdrawn and partially cooled off before another reading is taken.

This form of couple is the invention of Professor Wm. H. Bristol, formerly of Stevens Institute and now president of the Bristol Com-

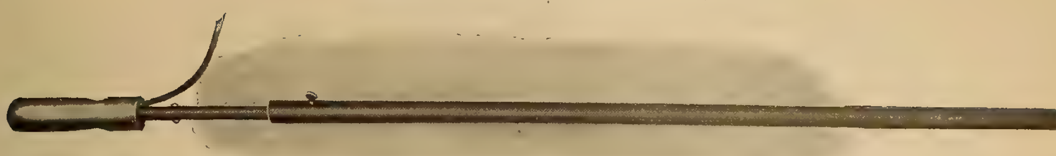


FIG. 2.—THE THERMO-ELECTRIC COUPLE WITH PROTECTING SHEATH OVER THE END

pany. United States patents were issued July 5, 1904, and August 29, 1905. The compound construction of this couple is shown in Fig. 3. The point *A* corresponds to the regular junction of an ordinary thermo couple, and the two elements which join at the point *A* are platinum and platinum-rhodium, this being the particular couple selected as a standard by the German Government. The platinum-platinum-rhodium elements extend to the points *B* and *C*, where they are welded to two other wires made of inexpensive alloys, which are such that the electro-motive forces generated at *B* and *C* are practically equal and opposed when these junctions are both exposed to temperatures not higher than 1,200 degrees F. These inexpensive alloy elements are extended to the point *D*, which is the cold end of the couple.

This construction of the quick-reading couple is such that the platinum-rhodium tip of the couple *A* may be exposed to excessively high temperatures up to 3,000 degrees F. without having the temperature of the junctions *B* and *C* exceed a safe limit. The temperature at *A* may be quickly measured with this special couple, as the platinum-rhodium tip is exposed directly to the hot gases in the furnace or kiln. In this way an inexpensive substitute is provided for the expensive platinum-rhodium couples previously employed for the measurement of such high temperatures.

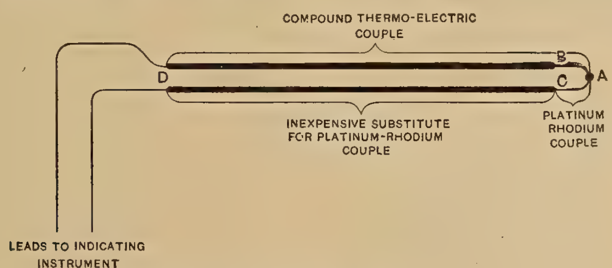


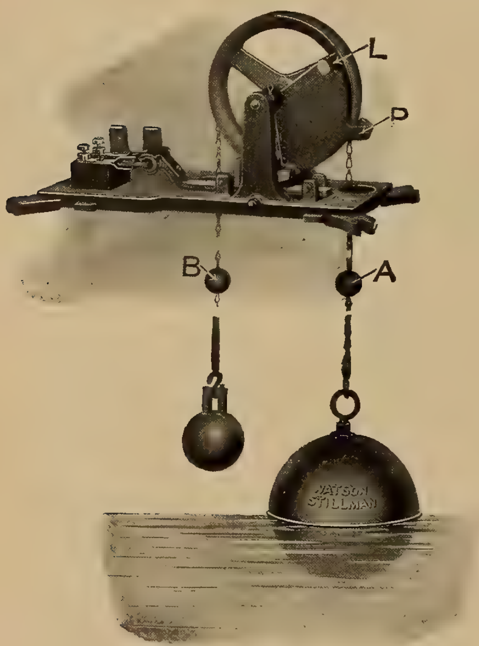
FIG. 3.—DIAGRAM SHOWING THE PARTS OF THE COMPOUND THERMO-ELECTRIC COUPLE

This quick-reading form of the Wm. H. Bristol electric pyrometers with the patented compound couple has been tested under very severe conditions and found extremely valuable for such applications as brick kiln temperatures, boiler furnace fire-box temperatures, by-product coke oven combustion flue temperatures, soaking pit temperatures, etc. The complete outfit is portable, and readings of temperatures in the neighborhood of 2,500 degrees may be obtained in a very few seconds after inserting the tip of the couple to the point where the temperature is to be measured. By using a special form of the platinum-platinum-rhodium tip this type of thermo couple can be used to measure the temperature of red-hot surfaces of any material.

When the electric pyrometer was first brought out it was considered to be a refined and delicate device, adapted for the physical and chemical laboratory. To-day, as a result of the efforts of Professor Bristol, it has become a reliable and useful tool in the manufacturing and metallurgical establishment, acquiring great commercial value without losing any of its precision or accuracy.

The New Watson-Stillman Automatic Tank Switch

THIS device is offered as a decided improvement over other switches for automatically maintaining the water level between desired limits in open-tank or sump systems. The construction is novel, permitting the switch to be placed on top of the tank or sump cover, and permitting any desired variation



THE WATSON-STILLMAN AUTOMATIC TANK SWITCH

in water levels to be carried without re-locating the electrical apparatus. When the switch is placed on top of the tank, as in this instance, there is no necessity for boring a hole into the side of the tank and there is no danger of the switch flooding and becoming short-circuited.

The operation of the Watson-Stillman switch in starting and stopping the motor is dependent upon the movement of a falling hammer, the movement of which, in turn, is governed by a freely suspended copper float nearly counterbalanced by a cast-iron ball. Referring to the illustration of the interior mechanism, which is shown arranged for tank service, the two small wooden balls on the chain are adjustable, and their position determines the variation of water level between operations of the pump. In the interior view the switch is shown as when the pump is in operation. As the float rises the bell *A* comes into contact with the projection *P* on the hammer and carries the hammer past the centre. The hammer then falls to the other side of the pulley shaft by gravity, and, in doing so, the lug *L* strikes a projection on the switch and disengages the knife, thus stopping the motor and pump. The switch movement is quick. There is no chance for arcing, and as the hammer remains in contact with the switch arm, there can be no rebound. The hammer holds the switch arm in this position until falling of the water level brings the other wooden ball *B* into contact with the hammer lug, which reverses the hammer, throws the knife into contact and starts the pump again. The wheel acts merely as a carrier for the copper chain. It

AUTOMATIC TANK SWITCH FOR MINE SUMPS.

plays no other part in the operation of the switch.

As arranged for draining sumps, the copper float and iron ball are reversed, as shown in the exterior view. This reverses the switch action to start the pump when the water level gets too high. Dampness will not affect the working qualities of the switch when it is placed in the pit. The knife arm is thoroughly insulated from every other part of the switch and the two contact points are mounted upon a slate block. A suitable opening is provided in the body for inserting the tube and making the connection to the binding posts. No parts of the switch need oiling or other attention. The shaft is bronze, to prevent corrosion, and all parts are extra strong. All working parts are enclosed in a heavy cast-iron case, which protects them from the weather and from sudden injury.

This switch may be had single or double-pole and for all ordinary currents and voltages. It is made by the Watson-Stillman Company, 50 Church Street, New York.

Westinghouse Bituminous Producer for Power and Heating Service

A WESTINGHOUSE bituminous gas producer for supplying fuel to gas engines, as well as furnishing gas for solder baths and enameling kilns, has been installed by the S. F. Bowser Manufacturing Company, maker of oil storage and distributing tanks and automatic weighing pumps, in its modern factory at Fort Wayne, Ind. This type T producer plant, of 350 horse-power capacity, supplies three 120 horse-power tandem horizontal engines direct connected to direct-current generators. These furnish power for the shops, which are motor-driven throughout. The equipment replaced by the present installation comprised three 150 horse-power Scotch marine boilers equipped with underfeed stokers, supplying steam to 50 horse-power and 125 horse-power simple engines. In the shops a large quantity of gasoline was formerly used for melting solder, while coke was required for the enameling kilns. Recognizing the superior economy to be obtained from producer equipment, as well as the advantage of doing away with gasoline and coke in its own special case, the Bowser Company decided to install a complete new equipment for gas engines and gas producers. The matter of selecting a bituminous producer was carefully weighed, and members of the firm visited a number of installations throughout the country to study the performance of the types in operation at the present time. The West Virginia coal, 13,000 B. T. U. per pound, used in the producer at present, is delivered at a cost of $2.55 per ton. A Green County, Indiana, coal of approximately the same heat value has been successfully experimented with, and will cost, delivered, $2.25 per ton. The installation has been under the supervision of Mr. A. A. Bowser, brother of the president of the company.

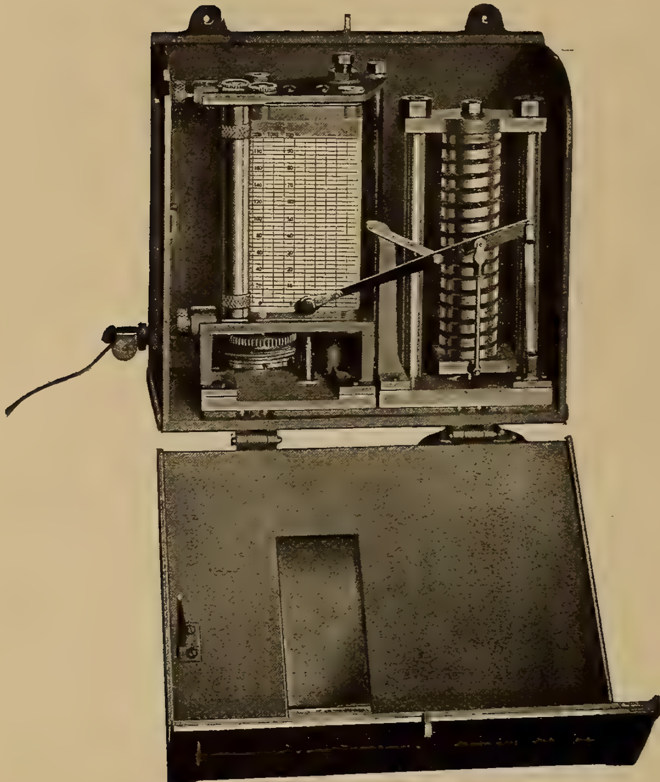
The Hydraulagraph

IN all car equipment, whether on steam or electric railroad, every detail which makes for strength or safety is so important that it hardly seems fair to select any one feature as being most important; yet if there is any one most important feature it must be the safety of the trucks.

Nothing is so baffling in public service, both to the railroad officials and to the State inspectors and commissioners, as the absence of a record assuring the original security or strength of material or careful inspection of every detail of car equipment before it has left the shop.

For instance, in the important detail of pressing wheels on axles there has never been discovered until now a successful method for making absolutely accurate diagrams of the ram movement in a hydraulic wheel press.

Such an instrument, however, has at last been produced, and, after



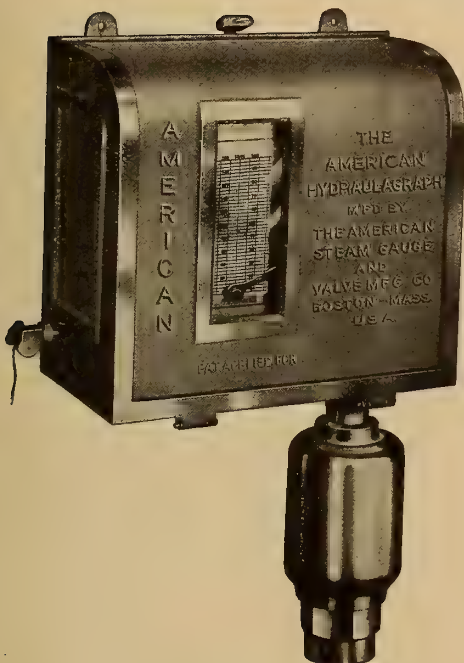
VIEW OF HYDRAULAGRAPH IN CASE.

thorough experiments, has been pronounced a success. It is a product of the American Steam Gauge & Valve Manufacturing Company, of Boston, and it is known as the hydraulagraph.

Prior to the invention of the hydraulagraph this company has, like many others, been manufacturing a maximum pressure recording gauge, which, while one of the best made, still failed to fully accomplish the purpose for which it was designed, principally because the operator, knowing that a maximum pressure was demanded, could get the prescribed reading on the diagram of the recording gauge by simply continuing the pressure after the wheel had reached the shoulder; when, in fact, the wheel might have been so loose that it was a menace to safety from the moment it was put on.

The hydraulagraph, however, is built on an entirely different principle, following the general design of a continuous steam engine indicator, but adapted to hydraulic work. By this method a spring of great power of resistance and unerring accuracy is obtained, and, by means of an air chamber to take up the vibration which naturally must follow the tremendous pressure of the wheel press running up into 200 tons, a diagram is obtained with as clear a line as the diagram of the American-Thompson improved indicator card.

The moment the operator attempts to get the required maximum pressure on a loose fit the diagram shows a vertical line. There is no way of disguising this, neither can the operator by any means obtain access to the diagram or pen. In fact, any effort on his part to hold the pen by means of such ingenious devices as he might make to reach down to it would only



EXTERIOR VIEW OF HYDRAULAGRAPH

result in breaking the pen. The only portion of the diagram accessible to the operator, therefore, which is a necessary part of his work is the marginal space left for him to record wheel data, and one of the most valuable records achieved in recent years toward the safeguarding of the public.

The chart is 100 feet long, each quarter inch represents an inch movement on the ram, and the roll can easily record 400 complete movements or 200 pairs of wheels.

The enthusiasm with which we are told this instrument has already been received by our car wheel manufacturers and railroad men of the highest standing is sufficient warrant for believing it to be one of the most important factors of safety and one of the most valuable records ever secured on car equipment.

The records were made in actual shop practice, and the comment which is made in each instance will explain in the briefest and clearest manner the value of the hydraulagraph and its diagrams.

The Leblanc Condensers

THE Westinghouse-Leblanc condenser is the commercial development of one of the inventions of Monsieur Maurice Leblanc, a distinguished French scientist, who is, perhaps, best known to Americans on account of his electrical work. Among his more important electrical inventions may be mentioned the copper 'damper" or "amortisseur," so extensively used on alternating current generators, and which brought his name very prominently before the public some ten or twelve years ago, when the problem of operating alternators in parallel was the all-absorbing topic with which electrical engineers were concerning themselves.

In 1900 Mr. George Westinghouse, with his characteristic foresight, secured control of Mr. Leblanc's inventions and enlisted his personal services. The Leblanc patents have been so numerous, and so basic in their nature, that their exploitation and the granting of licenses under them soon became so important as to warrant the formation of a company to care for this business exclusively. This company, of which Mr. Westinghouse is chairman, is known as the Société pour l'Exploitation des Procédés Leblanc.

Mr. Leblanc is consulting engineer to the French Westinghouse Company, and is also professor of physics in the Ecole des Mines, at Paris. His versatility is well illustrated by the fact that he formerly occupied the chair of mathematics, and is equally well qualified to fill the position of professor of chemistry or astronomy.

Reports from all over the United States point to an early and extended development in all lines of industry which are dependent upon railway activity, and there is every reason to believe that the demand for railway supplies in the coming year will be unusually great.

News Items

Allis-Chalmers Company has received a contract for the construction of the largest city pumping engine in the world. The engine is to supply water for the city of Wheeling, W. Va., and is of the triple-expansion, crank and fly-wheel, standard Allis-Chalmers type.

This is the largest pumping engine used to supply water to a municipality, the low-pressure cylinder of which will be 110 inches in diameter by 72 inches stroke. The engine will have a capacity of 20,000,000 gallons a day, and will have to pump against a regular domestic water pressure of 150 pounds per square inch. There will be two 20-foot fly-wheels, weighing 100,000 pounds each. The total weight of the engine will be about 2,225,000 pounds. Allis - Chalmers shops are better equipped for this large work than any other shops in the United States, or, for that matter, in the world.

The contract for placing Raymond concrete piles in the six-story reinforced concrete factory building that is being erected for Brewster & Co., carriage builders, at the Queensboro Bridge Plaza, Long Island City, N. Y., has been awarded to the Raymond Concrete Pile Company, of New York and Chicago. Stephenson & Wheeler, architects; Tucker & Vinton are the general contractors.

A student of Sibley College, Cornell University, inquiring as to how much credit he would obtain for shop work done during the vacation, was told that it was the practice to give one hour's credit for every two hours devoted to actual work in a shop or foundry, provided the latter were approved by the faculty as a proper place for gaining useful experience.

Asking if the Yale & Towne Works at Stamford would fit this description, he was informed that double credit would be given for any time spent in these works, as, in the opinion of the faculty, it was the full equivalent of the instruction given at the college, and that in this respect it ranked with a very few of the leading industries of the United States.

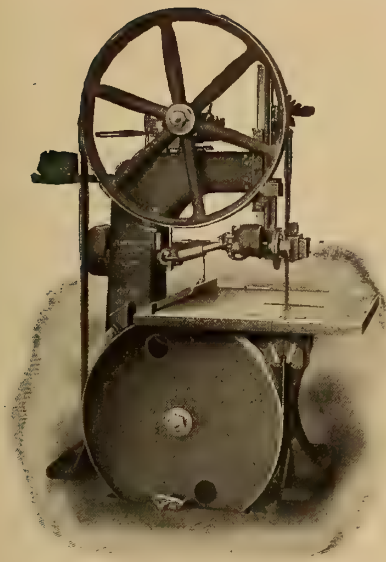
Mr. George H. Frost, president of the Engineering News Publishing Company, has just placed a contract with Frank B. Gilbreth, 60 Broadway, New York, for the construction of a brick and reinforced concrete building, to be used as a publishing house.

This building will be strictly fireproof and modern in every respect. Frederick A. Waldron, 37 Wall Street, New York, has been retained as architect and industrial engineer in charge of the mechanical layout of the plant.

The Monarch Lumber Company, of Portland, Ore., has installed two 500-kilowatt Westinghouse steam turbines in its mill at Stockdale, Ore., which will be employed to drive 2,300-volt, three-phase, 60-cycle, alternating-current generators supplying the local lighting and power load.

Mr. F. C. Armstead, supervising engineer of the stoker department of the Westinghouse Machine Company, who for a number of years has been located at East Pittsburg, Pa., has moved his headquarters to the Westinghouse Works, Attica, N. Y., where the stokers are manufactured.

With reference to rumors recently circulated to the effect that large shop and foundry extensions are to be undertaken this fall by Allis-Chalmers Company, it has been authoritatively stated by President W. H. Whiteside that no further additions to the West Allis Works are contemplated. However, an extension to the Cincinnati Works of the company is being made, which will give employment to about 1,000 additional men. Construction work and the installation of new equipment were commenced there some weeks ago.



FAY & EGAN BAND RIP SAW

A Band and Rip Saw for General Ripping

THE machine illustrated herewith is the most popular band rip saw for general ripping manufactured by the J. A. Fay & Egan Company, 226-246 West Front Street, Cincinnati, Ohio. It is equally efficient in ripping light and heavy material, because it will run a very thin blade at a high speed—two essentials to the rapid and economical production of fine lumber.

The high speed is obtained by the application of the company's patent knife-edge straining device and solid lower wheel. The machine has capacity for ripping material up to 24 inches wide and 12 inches thick.

In the descriptive circular recently issued by the company this machine is illustrated with motor drive. This is applied to all the 500 different woodworking tools made by the J. A. Fay & Egan Company.

The advantages of the band-saw for all kinds of work are now fully appreciated, but these advantages cannot be realized unless the machine and the saw are made in accordance with correct mechanical principles.

Belts and Dressings

AFTER a belt has been in use some time its surface takes on a glaze. This results in losses due to slipping, always accompanied by heating, and draws the natural oils to the surface, causing them to evaporate. This condition further leads to the belt's getting stiff and hard, and lessens the angle of wrap (the angle between the extreme points touched by the belt on the pulley).

Without attention belts are almost sure to deteriorate as above described. Their efficiency is increased and their life lengthened according to the treatment they receive.

Rosin is very frequently applied to prevent slipping, and this it will do; but at the same time it destroys the life of the belt itself.

Dixon's traction belt dressing has through long service proved its value in preserving belts at high efficiency. It does not supply a surface stickiness, but is absorbed by the belt, thus keeping it in its natural condition, preventing the formation of surface glaze with the attendant slipping, and maintaining the angle of wrap at its widest points.

If any readers have belt troubles or wish to insure themselves against these troubles, they should take up this matter of the proper care of belts with the Joseph Dixon Crucible Company, of Jersey City, N. J.

An idea of the rate at which work on the Panama Canal is progressing can be formed by the way the records for excavating are broken.

The record is held by Bucyrus Shovel No. 220, which excavated 3,941 cubic yards in 6 hours and 50 minutes. This is a 95-ton shoved, and the record was made on March 2, 1909. Other remarkable performances are those of Shovel No. 58, which excavated 1,356 cubic yards on February 5, 1908, and No. 131, which excavated 2,300 cubic yards on February 9, 1908. They are both Bucyrus shovels, and are of 45 and 70-ton capacity respectively.

THE LATEST CATALOGUES

Phosphor Bronze

The Phosphor-Bronze Smelting Company, Philadelphia, Pa. Price List No. 24, describing the various grades in which Elephant brand phosphor bronze is made. Some of the uses for which these alloys are especially suited are the making of machine castings, cogwheels, propeller screws, valves, cocks, cylinder linings, pumps, plungers and bearing metal.

Injectors

Penberthy Injector Company, Detroit, Mich. Catalogue No. 24 gives illustrations and price lists of Penberthy automatic injectors, auto-positive injectors, ejectors, oil and grease cups and steam specialties.

Engineering Specialties

The Wm. Powell Company, Cincinnati, Ohio. The illustrated catalogue and price list No. 9 covers the latest designs in brass and iron steam specialties manufactured by this company.

Gas Engines

The National Meter Company, New York, N. Y. A new catalogue divided into two parts, treating on gas engines in Part I. and on producer gas and gasoline engines in Part II.

The John H. McGowan Company, Cincinnati, Ohio. Catalogue No. 30 gives illustrations, together with descriptions, tables of sizes and code words, covering the various styles of single-cylinder steam pumps manufactured by this company.

Blowing Engines

Southwark Foundry & Machine Company, Philadelphia, Pa. Handsomely illustrated catalogue describing blowing engines made by this company.

Air Compressors

The Norwalk Iron Works Company, South Norwalk, Conn. Catalogue of air and gas compressors. The subject of air compression is treated as far as necessary to explain the merits of the system of this company.

Boilers

The Heine Safety Boiler Company, St. Louis, Mo. Handsomely illustrated catalogue giving illustrations of the company's shops at Phœnixville, Pa. The construction of the boiler is also gone into.

Perforated Metals

The Hendrick Manufacturing Company, Carbondale, Pa. Catalogue in which are shown a number of perforated sheets and special screens to meet the requirements of industrial and domestic purposes.

Buckets

The Hayward Company, 50 Church street, New York, N. Y. Catalogue No. 33 by this company illustrates four types of Hayward orange peel and six types of clam shell buckets. From these ten designs a bucket suited to almost any character of digging or re-handling may be selected.

Wood-Working Machinery

J. A. Fay & Egan Company, Cincinnati, Ohio. Catalogue illustrating and describing the various kinds of wood-working machinery made by this company such as are specially adapted for saw and planing mills, box factories, furniture, coffin, chair and basket factories, bridges and agricultural work, etc.

Patents

"How to Obtain a Patent" is the name of a pamphlet published by Victor J. Evans & Co., of Washington, D. C. It is a complete compendium of useful information for inventors.

Chains

Link Belt Company, Chicago, Ill. Catalogue No. 75 is a very complete and elaborate publication, containing price list of the many styles of chains, link belts, etc., manufactured by this company.

Coal-Handling Machinery

J. M. Dodge Company, Philadelphia, Pa. Book No. 70 treats on the handling and storing of coal and ore, and contains a number of illustrations showing their systems.

Files

G. & H. Barnett Company, Philadelphia, Pa. The new edition of this company's catalogue has just been published. A great variety of files and rasps are illustrated therein.

Steam Hammers

Chambersburg Engineering Company, Chambersburg, Pa. The most recent designs of hydraulic machines and steam hammers are treated in Booklet No. 33 published by this company.

Lathes

The American Tool & Machine Company, Boston, Mass. A new edition of this company's catalogue has just been issued, in which extensive lines of lathes, valve milling machines and oil separators are very aptly described.

Instruments

Weston Electrical Instrument Company, Newark, N. J. Catalogue No. 15, being a handsomely illustrated book of more than a hundred pages, devoted to the setting forth of the construction and advantages of the Weston standard voltmeters and ammeters, both for portable and station use, and for direct and alternating currents. The reputation of these instruments is so highly established that nothing need be said in that respect, while the manner in which they are presented in this catalogue is an indication in itself of the character of the output of the manufacturers.

Locomotives

Baldwin Locomotive Works, Philadelphia. Illustrated catalogue of locomotive and detail parts, including a historical sketch of the development of the locomotives in the United States, followed by specifications, class designations, and finally by a series of illustrations and descriptions of nearly fifty different types of locomotive engines, simple and compound. To this is appended a list of detailed parts, with cipher code for ordering, the whole forming a treatise upon locomotive design and construction of nearly 500 pages, bound in cloth, and being a notable contribution to engineering literature.

Mining Machinery

Allis-Chalmers Company, Milwaukee, Wis. Bound set of bulletins, covering detailed and illustrated descriptions of all kinds of machinery for use in mining operations, including crushers, samplers, stamps, screens, jigs, etc. The subject of cyanide plants is fully treated, also furnaces, accessory equipment of all kinds, and the necessary power appliances.

Cranes

Pawling & Harnischfeger, Milwaukee, Wis. General catalogue, seventh edition, devoted to the subject of electric cranes and hoists, and containing numerous illustrations of recent installations in manufacturing establishments in all parts of the United States. This book is an excellent example of the presentation of machinery of the highest class in a manner fully in accordance with the products illustrated.

Electrical Machinery

Triumph Electric Company, Cincinnati, Ohio. Collection of bulletins illustrating and describing electric generators and motors for direct and alternating current, and of belted and direct-connected types. Numerous applications of electric drive using Triumph motors are shown and useful suggestions given to aid in the selection of apparatus.

The Mechanical Shovel

THE spade is one of the oldest implements of labour, its use is synonymous with the idea of manual effort and drudgery. From the earliest times down to very recent days, practically all the work of excavating, handling, and removing earth, rock, minerals, and the like has been effected by human labor applied to this simple tool.

Some of the greatest monuments of ancient and modern times have been raised by the aid of this primitive implement, and even with the development of improved appliances for loosening and transporting material, it has remained for comparatively recent times to effect an advance upon the ordinary shovel for the ultimate moving of nearly every loose substance.

That it is desirable to replace such a crude device as the ordinary shovel by some more effective appliance has become increasingly evident as manufacturing and engineering work has become expanded. Individual workmen require skilled supervision, even in so simple a task as shoveling dirt, or the result is apt to show a very low efficiency. Attempts to secure a large result by putting on a great number of men are often disappointing, as the men get in each other's way unless the work is of such a nature that they can be spread over an extended line.

When, as is often the case, the excavation is to be effected in soft and wet ground, or even beneath the surface of water, it is still more difficult to secure good results by unaided human labour, and there are many situations in which men can scarcely work at all.

Apart from the physical difficulties and objections to the use of ordinary hand implements for excavating earth and handling materials there are certain sociological questions which apply to nearly every study of the replacement of manual labour by machinery, but which relate with especial force to this particular department of work. Every step made in the substitution of a machine for a man is a step upward in the relief of mankind from the burden of laborious effort, and is consequently a contribution to the amelioration of the condition of the human race. This fact is better seen by comparing the results of the development of machinery upon society over a long period of years than by examining any particular case for any limited period. Its truth becomes evident upon examination, and is now generally accepted.

Another and equally important point is the fact that one of the great sources of industrial and labour troubles is minimized, and in some cases wholly removed, by the substitution of the machine for the man. By far the greater portion of labour difficulties arise in those departments of work in which the men work with their hands rather than with their heads, and when the brutal part of the work is transferred to machinery, leaving the control and direction to the intelligence of skilled workmen of higher grade, a large part of the cause of trouble is removed.

Thus there has been developed, in recent years, a line of special appliances designed for the accomplishment, on a large scale, of the work formerly done by manual labour in the handling of materials. The earlier types of hoisting and conveying machinery were devoted almost entirely to the movement of the load after it had been shoveled into the bucket, and there was still an enormous amount of labour to be done by hand and shovel. To-day this is being effected by the so-called "grab" buckets, mechanical shovels which are lowered into the material, closing upon it automatically with great power and dumping it to any point where it may be conveyed. The machine has replaced the man in one of his most laborious capacities, and another step forward has been effected.

Powerful Chain Blocks

ONE of the interesting problems in mechanics which has appeared in many forms is that of increasing the power or capacity of a device by some form of duplication. This is a simple matter in certain instances, but in other cases it involves the exercise of considerable ingenuity in the arrangement of parts in order that the effectiveness or efficiency of the original device may not be impaired.

One of the simplest instances of such a duplication appears in the case of a pair of horses attached to a vehicle when the burden is too great for one animal. It is practically impossible to be assured that two horses will pull exactly alike; but by the interposition of the simple device of an equalizing lever, in the form of a whiffletree, the resultant of both efforts is transmitted to the vehicle.

The use of a similar device has rendered the modern powerful locomotive engine a practical machine. The early locomotives were made with a single pair of driving wheels, and when a greater tractive power was desired it was suggested by Campbell that an additional pair of drivers would accomplish the desired result. In practice, however, it was found impossible to provide springs of the same stiffness over all the wheels, and thus the actual driving was effected by but one pair until Harrison introduced the equalizing lever, which made it possible to distribute the load upon all wheels alike, and rendered it practicable to extend the tractive power indefinitely.

In the case of hoisting machinery a similar development has occurred. The ordinary chain block is generally considered as a device of moderate capacity, ranging from the differential block of one-eighth ton to the duplex or Triplex block of five tons, or possibly of ten tons capacity in an extreme case. As a matter of fact, the Triplex block has been regularly made up to twenty tons capacity for years; and now, by the use of the method of duplication already referred to, it is made capable of hoisting forty tons. This result is attained by using two 20-ton units provided with equalizing bars at top and bottom, these furnishing a single point for suspension and a single point for attachment of the load. The equalizing bars are made of two channels, placed back to back, with separators, the suspensions being in the form of clevises, permitting the hoist to be put in place easily and affording a convenient point for connecting it to the load. By arranging each unit so that it may be swivelled at top and bottom, the whole combination can adapt itself to the conditions of use, a maximum degree of flexibility thus being secured.

The desirability of providing a chain-block combination of this capacity appears when it is considered that there are many positions in which the installation of an electric crane or powerful steam hoist would be impracticable, either by reasons of time or cost, or because of the temporary nature of the undertaking. Thus, there are many situations in which heavy pieces have to be handled at the time of the original installation of the plant, but which are much greater than occur in subsequent service, so that it would be an unnecessary expense to install a heavy crane for such a limited effort. Again, in marine or land wrecking work a powerful combination is required for prompt service for but a single occasion, and the powerful chain block is immediately available. In mines or quarries, in building or manufacturing operations, and in military work where heavy ordnance has to be placed promptly in position, a machine capable of handling burdens up to forty tons without involving the use of steam or electric power becomes of immeasurable value, since two, four, or even eight men may work to advantage with high efficiency.

The Care of Boilers

IN the development of power from heat by means of steam there are many details demanding attention as auxiliaries, and these form by no means unimportant elements in the power plant. The steam generated in the boiler represents the first stage in the operation, its expansion in the engine or turbine may be called the second stage, and its transmission, either by belt, rope or other flexible device, or by the aid of the electric current, completes the delivery as power of the latent energy in the fuel.

In order that these operations may be effected and maintained at a high degree of efficiency it is essential that all losses be kept at a minimum. Many opportunities exist for the escape of heat, and many impediments appear in the course of its conversion and transmission. Some of these are unavoidable, and are inherent in the physical nature of the problem; others come fairly within the province of the engineer for his study and solution.

In the case of the steam boiler the methods of securing the maximum degree of efficiency belong partly to the original design and partly to the method of operation. Among these latter one of the most important is that of maintaining a clear interior surface. The outside of a boiler, the portion exposed to the action of the fire, may be examined and any deposits of soot and ash removed without much difficulty. The interior, however, is a more troublesome matter, both as regards the opportunity for inspection and in respect of the nature of the deposit. Very few waters, in their natural condition, are fit to be put directly into a steam boiler. The housekeeper knows well how the interior of even so simple a boiler as the kitchen kettle becomes coated with deposits of baked earth and of crystallized and calcined minerals, and has learned by experience how hard and adherent such deposits are formed. In the steam boiler these deposits are still harder and more troublesome, both by reason of the higher temperatures and pressures and because of the greater volumes of water evaporated.

Some waters are soft, as it is termed, containing little or no mineral substances in solution, and yet contain earth and clay in suspension, in the form of mud, which, although but slightly visible to the eye as a moderate degree of turbidity, will form hard earthy deposits, baking fast to the heated metallic surfaces of the boiler. Other waters—and these are in the majority in the interior of the country—contain salts of calcium and magnesium, usually in the form of carbonates and sulphates, and are commonly termed "hard" waters.

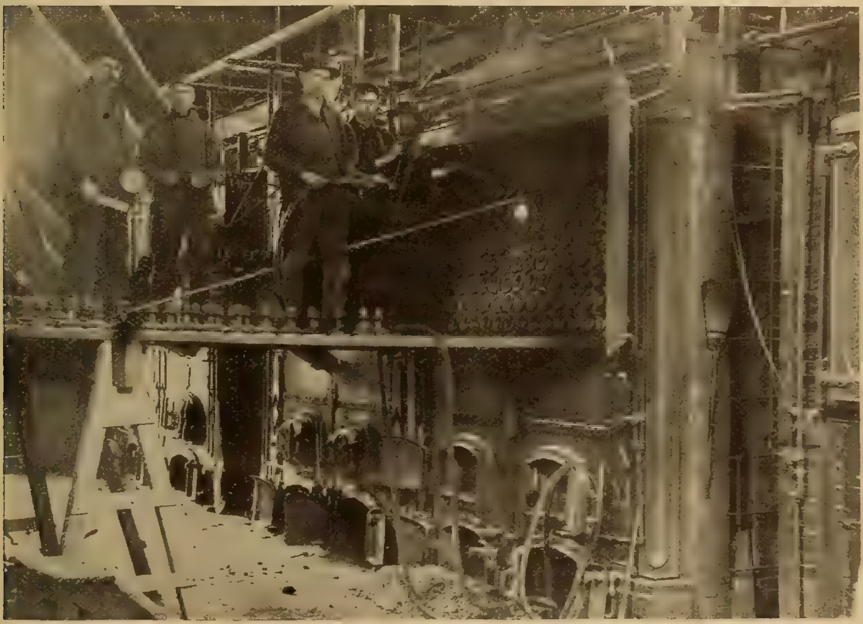
To put such a material into a steam boiler and evaporate it in large volumes, thus concentrating the matter in suspension, and at the same time exposing it to temperatures sufficiently high to precipitate the salts in solution and cause them to adhere to the metal in coatings as hard as rock, such a performance is wholly unscientific, wasteful and elementary.

There is evidently but one way to keep the interior of a boiler clean, and that is to put only clean water into it. This is effected in the case of plants using surface condensers by using the same water over and over again, although even in such instances it becomes necessary to remove the oil which it has taken up.

In every well-regulated power plant, therefore, there should be some apparatus for purifying the feed-water, both by providing opportunity for the settling of mud and by causing the precipitation of the dissolved salts. There is no more important factor in the care of a steam boiler than that of keeping it clean inside, and the way to do this is to put no dirt into it in any form.

Frequently the operation of purifying may be combined with the heating of the feed-water, and thus a double advantage secured.

DODGE



The above illustration shows cleaning gang drilling out scale in B. & W. Water Tube Boilers. Boilers had formerly to be opened and cleaned every four weeks. A "Eureka" Water Softener was installed over two years ago, and since that time boilers are opened only once each six months for insurance inspection. "Tubes, heaters and other connections free from scale, deposit or corrosion," is now the invariable report of the Insurance Companies.

Your Choice:—Scale Or No Scale—Which?

If your feed water has the scale-forming habit, don't wait until it gets into the heater or boiler before applying the cure. It's too late, then. The only *sure* remedy is to

Remove the incrusting solids from the raw water.

It is then *impossible* for scale to form in your heaters, boilers, pipes and pumps. Let us convert your hard water into a soft, non-incrusting supply by installing a

"EUREKA" Water Softener and Purifier

The treated water is ideal for high-class industrial work, such as dyeing, bleaching, general textile manufacture, laundering, etc. Our literature contains facts and figures that will interest you. Sent free upon request.

OUR MOTTO: Treat the water *before* it enters the boilers.

DODGE MANUFACTURING CO.
Station J-11 Mishawaka, Indiana

The Handling of Materials

MATERIALS of consumption, as they have been called, to distinguish them from materials of construction, demand especial appliances in order that they may be handled most effectively. Such substances as coal or ore, for example, have to be received, unloaded, deposited in predetermined places, and subsequently removed and re-delivered to places where they are consumed. This often means that large areas are to be covered with materials in great bulk in comparatively short spaces of time. The work must be done by few men, who can command powerful machinery and control the results without delay, since the elements of time and of promptness must be beyond question.

At the present time the influence which apparatus of this kind has upon modern methods of manufacture is greater than is everywhere appreciated. The commanding position which the United States has attained in the manufacture of iron and steel is almost wholly due to the development of mechanical appliances for effecting things which were formerly done by human labour. The result is that the work is done on a far larger scale; the quantities of ore and fuel handled are proportionally greater; the furnaces are bigger and are pushed harder, and the enormously increased volume of work performed makes possible the results which have so changed the commercial features of the industry.

The changes which have taken place in the manufacture of power are also largely due to the possibilities attainable in the handling of fuel. The distribution of power-generating plants at many points in a city, necessitating hauling of coal and repeated shoveling, has been largely replaced by the erection of large electric generating stations either by the water-side, where water-borne fuel can be raised directly to elevated storage bins and allowed to flow to the chutes of automatic stokers, or the coal is brought by rail in cars of maximum size and deposited upon storage grounds by bridge tramways or other coal-storage appliances ready for delivery to the boilers.

The development of systems for the storage of coal and ore in bulk has been greatly advanced by the introduction of electric power, since it is now practicable to deliver energy to any desired point in a more convenient manner than was possible when steam pipes or mechanical transmission formed the only available methods. To-day either direct or alternating current is largely used in such installations, and as current is always available at power stations, there is no difficulty about the replacement of manual effort by electricity. It follows that the production of power in bulk has been directly influenced by the possibility of storing fuel in bulk and thus freeing the administration of the modern power plant from the necessity of handling coal in driblets in slow and expensive ways.

The extent of some of these coal-handling installations will be realized when it is understood that they range in capacity from 50,000 tons to nearly 500,000 tons, including both the storage plants of the great coal mining and operating corporations and those of the large fuel consumers, the manufacturers of iron and steel and the manufacturers of power and electricity.

An example of a great storage plant for coal is seen in the "Bridgeport Transfer" of the Philadelphia and Reading Coal & Iron Company, at Abrams, Pa. The tonnage of this plant is divided into eight piles, four on each side of a central railway system, each pile having a capacity of 60,000 tons, or 480,000 tons in all, the machinery being capable of stocking 1,800 tons per day upon each pile. The fuel thus stocked can be handled by reloading conveyors into cars, the reloading capacity of the plant being 10,000 tons per day of ten hours.